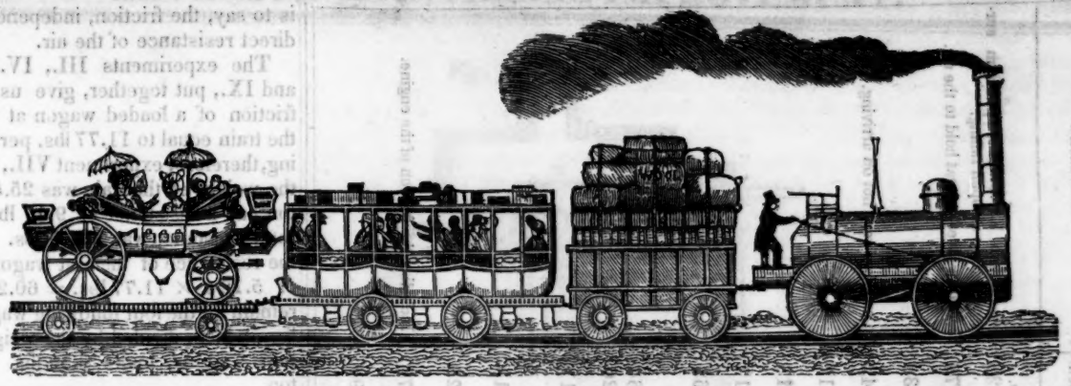


AMERICAN RAILROAD JOURNAL,
AND ADVOCATE OF INTERNAL IMPROVEMENTS.

PUBLISHED WEEKLY, AT NO. 132 NASSAU STREET, NEW-YORK, AT FIVE DOLLARS PER ANNUM, PAYABLE IN ADVANCE.

D. K MINOR, Editor.] SATURDAY, JUNE 4, 1836. [VOLUME V.—No. 22

CONTENTS:

Notice to Railroad Contractors; To Contractors..337
Editorial Notices.....337
Pambour on Locomotion, continued.....337
Hosking's Portable Punching Press.....349
Agriculture, &c.....250
Advertisements.....352

AMERICAN RAILROAD JOURNAL.

NEW-YORK, JUNE 4, 1836.

NOTICE TO RAILROAD CONTRACTORS.

THE First Division of the BANGOR and OLD TOWN RAILROAD, extending from Bangor to Stillwater, will be ready for contract by the 15th inst., and sealed proposals will be received for the grading, masonry and bridging the same until the 25th inst., at the office of the subscriber in Bangor.

JOSHUA BARNEY, Engineer.

Bangor, June 2, 1836. 22—2t

TO CONTRACTORS.

PROPOSALS will be received at the Office of the Eastern Railroad Company, Boston, between the 28th and 30th inst., for the grading and masonry of said Road from East Boston to Newburyport, a distance of 33¼ miles.

The line of this road is along a favorable country, passing threugh Lynn, Salem, Beverly, and Ipswich, which places will afford contractors every facility for obtaining provisions, &c. Plans and Profiles will be ready, and may be seen at the Office, after the 22d instant.

Satisfactory recommendations must accompany the proposals of those who are unknown to the Engineer.

22—t30j JOHN M. FESSENDEN, Engineer.

Maryland Internal Improvement Bill.—No legislative act, connected with Internal Improvement, out of our State, has given us so much pleasure as the passage of this bill. Our neighbors of the Monumental City have celebrated the event by various festivities. They have good reason to rejoice, inasmuch as the rapid completion of several of their most valuable public works is now ensured to them.

We cannot but think, however, that to the passage of the Erie Railroad Bill, the Marylanders are indebted for their own success. They boasted of their great advantages over New-York, and her public works—we, not to lose what we have so long enjoyed, grant increased facilities to our companies, and now, they determined to try our metal, have lent a helping hand to their favorite works. We hope this profitable rivalry may long be continued in as good feeling as it has commenced.

We perceive that the "Broome County Courier," published at Binghampton, is for sale. The editor, J. R. Orton, Esq. "in consequence of impaired health, which it seems probable nothing short of a temporary change of climate will restore, offers for sale the Establishment of the Broome County Courier, and his Bookstore. His press, materials and business are decidedly good—and to those acquainted with the location and prospects of Binghampton, and with the fact, that the Courier is the only democratic journal in the county of Broome, in which there is but one other newspaper of any description, nothing farther will be needed to illustrate the value of the location. He will also include in the sale, his new building, fitted up expressly for a general Printing and Book publishing Office, Bookstore and Book-Bindery; or he will rent the building for a term of years.

If a sale is not effected within a short period, the subscriber would form a partnership in business."

We consider Binghampton an important point on the line of the New-York and Erie Railroad. It lies at the junction of two branches of the Susquehannah River; and it is also the termination of the Chenango Canal. Binghampton is certainly destined to become a place of considerable importance.

Scarcity of Instruments.—It is now pretty generally understood by Engineers, that there is a very great scarcity of *Instruments* for their use in market at this time. There is scarcely a first rate Leveling instrument to be had in New-York; it is therefore a matter of some importance to those who intend to procure them to give their orders in time to have them manufactured, or imported.

Should it be desired, we will answer inquiries in relation to, or give orders for instruments either of American, or European manufacture.

We have received from our Paris correspondent a description, with views and plans, of the St. Germain Railroad.

As this is a work intended to excel in appearance (passing, as it does, the vicinity of many splendid structures), and also in solidity of construction, we shall endeavor to give our readers a translation of such of them as may be interestiag or useful.

We have received Williams' Annual Register for 1836. This work, always valuable for the statistics collected by its enterprising publisher, appears this year much increased in size, and equally so in usefulness. When it is recollected that the same amount of information is not to be procured in any other form, due credit will be given to the perseverance of the proprietor, who has given it to us in such a convenient and portable form.

We notice numerous articles of interest and value in addition to the usual contents.

PAMBOUR ON LOCOMOTION.

Continued from page 328.

CHAPTER III.

OF THE RESISTANCE OF CARRIAGES MOVED ON RAILWAYS.

§ 5. *Table of the Results obtained in those Experiments on the Friction of Wagons.*

Bringing together the different experiments described hereabove, we make out the following table:—

EXPERIMENTS ON THE FRICTION OF WAGONS.

Number of the experiment.	Date of the experiment.	Description of the trains.	Weight of the train.	Weight per wagon.	Distance run over.	Duration of the race.	Difference of level.	Friction.	Friction per ton.	Observations.
	1834.		tons.	tons.	feet.		feet.		lbs.	
VI - -	July 29	1 empty wagon - - -	- -	1.85	6204	- -	36.78	1/169	13.28	This wagon has only a platform surrounded by an open railing.
VIII -	July 30	1 tender - - - - - -	- -	4.50	5967	- -	36.66	1/163	13.76	This form gives a great hold to the air.
III - -	July 29	1 loaded wagon - - -	- -	4.65	7326	- -	37.16	1/197	11.36	
IV - -	July 29	1 loaded wagon - - -	- -	5.15	6663	- -	36.95	1/180	12.42	An axle-box very hot on arriving.
V - -	July 29	1 loaded wagon - - -	- -	5.20	7455	- -	37.19	1/200	11.17	
IX - -	July 31	1 tender - - - - - -	- -	5.50	7266	- -	32.88	1/221	10.13	
II - -	July 29	5 loaded wagons - -	25.58	5.12	9324	10.20"	38.19	1/244	9.17	
I - -	July 29	5 loaded wagons - -	31.31	6.26	9933	10.00	38.55	1/258	8.69	
XI - -	Aug. 1	10 loaded wagons and 1 tender (11 carriages)	48.72	4.43	10008	11.45	38.58	1/259	8.64	
X - -	July 31	14 loaded wagons - -	61.65	4.40	9579	- -	35.32	1/271	8.26	
VII - -	July 30	19 loaded wagons - -	92.00	4.84	10728	11:00	38.85	1/276	8.11	
XII - -	Aug. 1	24 loaded wagons and 1 tender (25 carriages)	110.00	4.40	10668	- -	38.82	1/275	8.15	
XV - -	Aug. 15	7 wagons 1 tender and 1 engine in front	40.59	4.00	8175	8.30	37.35	1/219	10.23	Including the friction of the engine.
XIII -	Aug. 2	17 wagons 1 tender and 1 engine - - - - - -	94.96	4.78	11262	- -	39.10	1/288	7.78	
XIV -	Aug. 2	20 wagons 1 tender and 1 engine - - - - - -	110.14	4.83	10911	12.10	38.75	1/282	7.96	

During all those experiments the weather was fair and calm. As we have said before, no particular precautions had been taken, nor had anything been altered in the usual state of the wagons or rails. The circumstance of the trains passing over nine switches at the foot of the inclined plane, must make the results appear a little greater than they would generally be on any other part of the road taken at random.

§ 6. *Friction of the intermediate Wagons of the Trains.*

We have already marked in the first six experiments the influence of the resistance of the air in the results. When five wagons move together, their resistance to the motion is 9.17 lbs. per ton; and if each of those five waggons move separately, their average resistance per ton is 11.65 lbs. The other experiments present similar results. By comparing large trains with those which are composed only of a small number of carriages, we constantly see the resistance diminish, when the mass which is drawn, although continuing to cut the air on the same surface, comprises, however, a more considerable weight.

The direct resistance of the air takes place only on the first carriage of the train. Now, the first six experiments made with a single wagon give us the resistance of a carriage when it advances the first. Deducting it therefore, in the other experiments, we shall discover the resistance of the intermediate wagons of the trains; that is to say, the friction, independently of the direct resistance of the air.

The experiments III., IV., V., VIII., and IX., put together, give us the average friction of a loaded wagon at the head of the train equal to 11.77 lbs. per ton. Taking, therefore, experiment VII., for instance, the weight of the train was 25.58 t. Each ton had a resistance of 9.17 lbs.; thus the total resistance was 234.5 lbs. Deducting the resistance of the first wagon at the rate of 5.12 t. × 11.77 lbs. = 60.25 lbs., there remain for the four following wagons 174.25 lbs., which, divided by the weight of those four wagons, make 8.50 lbs. friction per ton.

§ 7. *Table of the Results of the foregoing Experiments on the Friction of the intermediate Wagons of the Trains.*

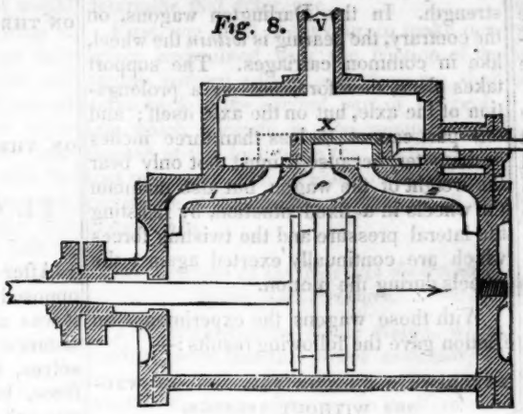
If we make the same calculations for each of the other experiments, and if we add to them the similar results, already presented for the three experiments where the engines had remained attached to the trains, the following table will be made out:—

RESISTANCE OF THE INTERMEDIATE WAGONS OF THE TRAINS, THAT IS TO SAY, AFTER DEDUCTION OF THE DIRECT RESISTANCE OF THE AIR ON THE FIRST CARRIAGE.

Number of the experiment.	Description of the trains.	Weight of the trains.	Average weight per carriage.	Resistance per ton of the first carriage of the train.	Resistance per ton of the intermediate wagons of the train.
		tons.	tons.	lbs.	lbs.
II - -	5 wagons	25.58	5.12	11.77	8.50
I - -	5 wagons	31.31	6.26	11.77	7.92
XI - -	11 carriages	48.72	4.43	11.77	8.33
X - -	14 wagons	61.65	4.40	11.77	7.99
VII -	19 wagons	92.00	4.84	11.77	7.91
XII -	25 carriages	110.00	4.40	11.77	7.99
XV - -	8 carriages	33.52	4.00	15.84	9.04
XIII -	18 carriages	86.76	4.78	13.78	7.21
XIV -	21 carriages	101.80	4.83	15.22	7.35
	126 carriages	591.00	4.78	"	8.03

The average resistance is therefore no more than 8 lbs. per ton, if we take into account only the intermediate wagons of a train. Now, in all the cases we have to calculate, in respect to railways, the train is always preceded by the engine. It is, therefore, upon that alone that the direct resistance of the air exerts its influence, and that resistance being already taken into account in what is called the friction or resistance of the engine, it is clear that all the wagons must be considered as intermediate

Fig. 8.



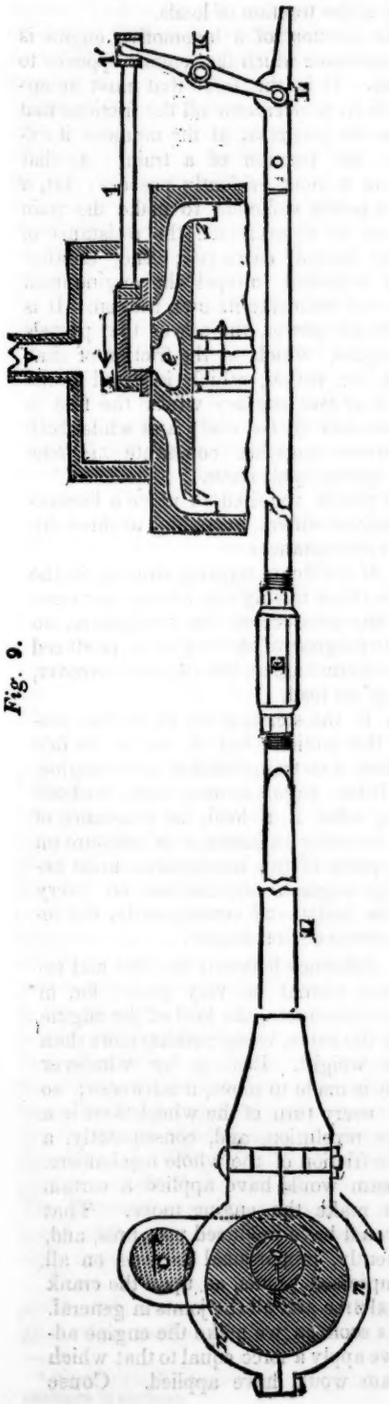


Fig. 9.

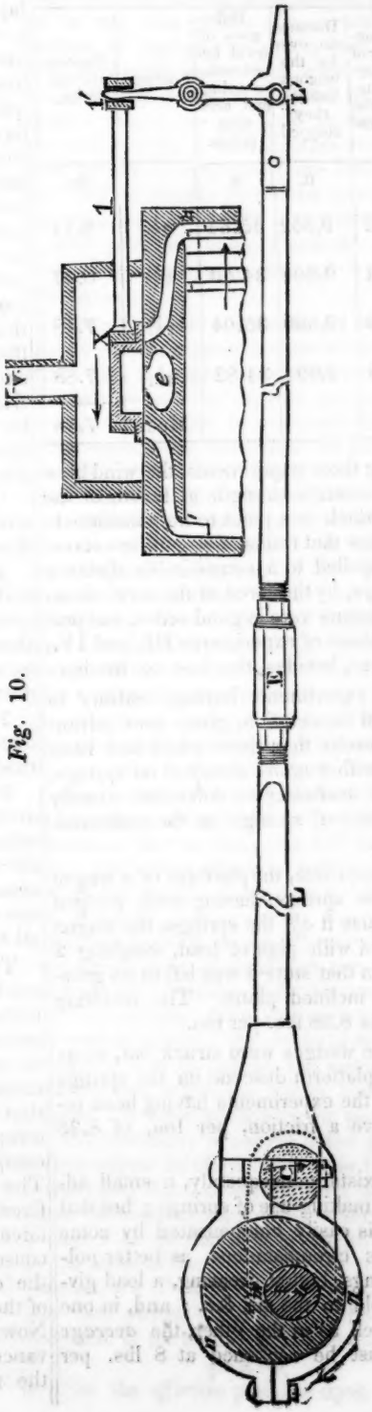
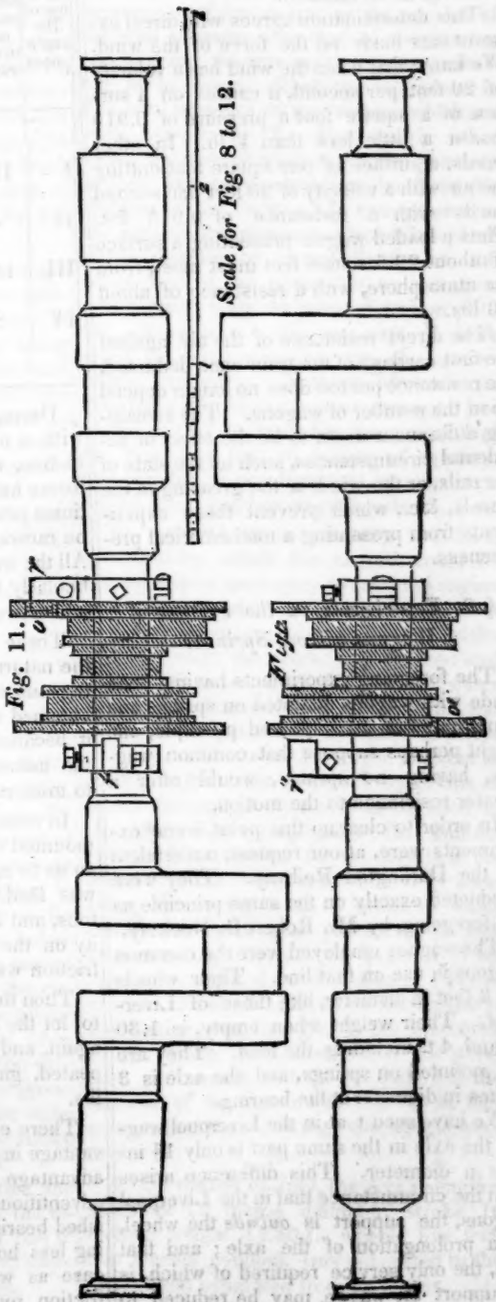


Fig. 10.



Scale for Figs. 8 to 12.

Fig. 11.

carriages. Consequently, their proper resistance must only be reckoned at the rate of 8 lbs. per ton. It is upon this proportion that we shall establish the resistance of the trains in all our experiments.

In the foregoing tables, the average weight of a wagon was 4.78 t. That wagon, placed at the head of the train, had a resistance of 11.77 lbs. per ton, or 56 lbs. for the whole; while, placed in an intermediate situation, its resistance was 8.03 lbs. per ton, or 38 lbs. in all. The difference between the results was owing to the obstacle of the air. The air created, therefore, a resistance of 17 lbs. to 18 lbs. on a wagon of a moderate height, as those were, and at the average speed of the experiments. That speed was of about 12 miles an hour, or 16 feet per second, a space of 10,000 feet having been, on an average, run over in 10 minutes.

This determination agrees with direct experiments made on the force of the wind. We know that when the wind has a velocity of 20 feet per second, it causes on a surface of a square foot a pressure of 0.915 lbs. or a little less than 1 lb. In other words, a surface of one square foot cutting the air with a velocity of 20 feet per second meets with a resistance of 0.915 lbs. Thus a loaded wagon presenting a surface of about 22.5 square feet must meet, from the atmosphere, with a resistance of about 20 lbs.

The direct resistance of the air against the first carriage of the train once deducted, the resistance per ton does no longer depend upon the number of wagons. The remaining differences seem to be the effect of accidental circumstances, such as the state of the rails, or the wind, or the greasing of the wheels, &c., which prevent those experiments from presenting a mathematical preciseness.

§ 8. *Experiments on the Friction of Wagons without Springs.*

The foregoing experiments having been made with wagons mounted on springs and constructed on an improved principle, one might perhaps suppose that common wagons, having no springs, would offer a greater resistance to the motion.

In order to clear up this point, some experiments were, at our request, undertaken on the Darlington Railway. They were conducted exactly on the same principle as the foregoing, by Mr. Robert B. Dockray.

The wagons employed were the common wagons in use on that line. Their wheels are 3 feet in diameter, like those of Liverpool. Their weight when empty, is 1.30 t., and 4 t. including the load. They are not mounted on springs, and the axle is 3 inches in diameter at the bearing.

We have seen t at in the Liverpool wagons the axle in the same part is only 1¾ inches in diameter. This difference arises from the circumstance that in the Liverpool wagons, the support is *outside* the wheel, on a prolongation of the axle; and that part, the only service required of which, is to support the wagon, may be reduced to so small a diameter without depriving the middle part of the axletree itself of its usual strength. In the Darlington wagons, on the contrary, the bearing is *within* the wheel, like in common carriages. The support takes place, therefore, not on a prolongation of the axle, but on the axle itself; and this part cannot be less than three inches in diameter, because it must not only bear the weight of the wagon, but also maintain the wheels in a fixed situation, by resisting the lateral pressure and the twisting forces which are continually exerted against the wheels during the motion.

With those wagons the experiments on friction gave the following results:—

EXPERIMETS ON THE FRICTION OF WAGONS WITHOUT SPRINGS.

Number of the exp'riment	Number of wagons in the trains	Distance run over by the wagons before they stopped.	Difference of level between the starting and arriving points.	Friction.	Friction per ton in lbs.
		ft.	ft.		lbs.
I	12	9,552	35.64	1/276	8.11
II	4	9,600	34.60	1/277	8.07
III	16	10,500	35.04	1/300	7.48
IV	8	9,894	34.82	1/284	7.88
				Mean	7.88

During those experiments, the wind blew with a moderate strength in favour of the motion, which is a point to be considered; for we know that trains of wagons are sometimes propelled to a considerable distance on railways, by the force of the wind alone. All the wagons were in good order, and particularly those of experiments III. and IV., which were, besides, the best on the line.

These experiments having, contrary to the naturnl expectation, given more advantageous results than those which had been obtained with wagons mounted on springs, it became necessary to determine exactly the influence of springs on the resistance to motion.

In consequence, the platform of a wagon mounted on springs, having been wedged so as to raise it *off* the springs, the wagon was loaded with pigs of lead, weighing 2 tons, and in that state it was left to its gravity on the inclined plane. The resulting friction was 8.58 lbs. per ton.

Then the wedges were struck out, so as to let the platform descend on the springs again, and the experiments having been repeated, gave a friction, per ton, of 8.35 lbs.

There exists, consequently, a small advantage in making use of springs; but that advantage is easily compensated by some adventitious circumstances, as better polished bearings, better greasing, a load giving less hold to the air, &c.; and, in one case as well as in the other, the *average* friction must be reckoned at 8 lbs. per ton.

CHAPTER IV.

ON THE FRICTION OR RESISTANCE OF THE ENGINES.

ARTICLE I.

ON THE FRICTION OF ENGINES WITHOUT LOAD.

§ 1. *Of the different modes of Determination.*

After having determined the resistance opposed by the loads that are to be moved, it was also necessary to ascertain the resistance belonging to the moters themselves, for it is only the surplus of their force, beyond the power they require to move themselves, which those moters can apply to the traction of loads.

The friction of a locomotive engine is the resistance which that engine opposes to motion. It is the force that must be applied to it, to overcome all the frictions that oppose its progress, at the moment it executes the traction of a train. At that moment it must evidently possess: 1st, a certain power sufficient to make the train advance or to overcome the resistance of all the loaded carriages; 2nd, another power sufficient to repel the engine itself along and overcome its own friction. It is this second power, the power that propels the engine, which is the friction of that engine, or, rather, which is equal to the *friction of that engine;* whilst the first is *the resistance of the load;* and whilst both the powers together constitute *the total power applied by the moter.*

The power required to move a locomotive engine differs according to three different circumstances.

1st. If the steam remains shut up in the boiler without having any access to, or exercising any pressure on, the mechanism, so that the progress of the engine be produced by an external agent, the engine, moreover, drawing no load.

2nd. If the steam is the agent that produces the motion; but if, as in the first case, there is no train attached to the engine.

3d. If the engine cannot move without drawing after it a load, the resistance of which, creating an increase of pressure on all the parts of the mechanism, must necessarily augment the friction on every one of its joints, and consequently, the total resistance of the engine.

The difference between the first and second case cannot be very great; for, in both circumstances, the load of the engine remains the same, being nothing more than its own weight. Besides, by whatever means it is made to move, it advances; so that at every turn of the wheel, there is a complete revolution, and, consequently, a complete friction of the whole mechanism. The steam would have applied a certain force to make the engine move. That force would have produced pressures, and, consequently, proportional frictions on all the compressed points, as upon the crank of the axletree and all the joints in general. Now, as soon as we make the engine advance, we apply a force equal to that which the steam would have applied. Conse

quently, we produce on the crank and on all the joints the same friction that would have been produced by the force owing to the steam. Of all these joints, those only upon which the steam acts in a direct and particular manner, cease to be compressed equally in the two cases. These parts being strongly pressed against one another, when the steam is admitted into the cylinders, cease to experience that pressure, and have, in consequence, evidently less friction when the steam takes no part in the creation of the motion. But the only parts on which the steam exercises a direct pressure are the two slides.

The surface of the slide, on which the pressure of the steam takes place, is, in general, 7½ inches long to 6 inches broad, or 45 square inches, which makes 90 square inches for the two slides together. When we talk of the engine moving alone, and without drawing any load after it, we cannot suppose that the pressure of the steam in the boiler need to surpass 10 lbs. We shall find, by experiment, that it may happen not to be above 4 or 5 lbs. The pressure exercised by the steam on the slides, amounts, therefore, at most, to 900 lbs. So that, taking the friction of iron on iron, ground and polished, at $\frac{1}{10}$ of the pressure,* we shall have a friction of 90 lbs. But we know that the real resistances on different points of an engine are in the ratio of the velocity with which those parts move. The slide only moves three inches for each stroke of the piston, or half a foot for each turn of the wheels; that is to say, that it only runs over a space of half a foot, while the engine having a wheel of five feet, advances 15.71 ft. The friction of the slide, considered as opposing itself to the motion of the engine, creates, therefore, a final resistance only $\frac{90}{2 \times 15.71}$ lbs. or about 3 lbs. From which we see, that, in practice, the friction occasioned either in the first case or in the second, may be considered as being the true friction of the engine, when it draws no load.

As for the difference between these two first cases and the third, we know that the friction is always in a direct ratio to the pressure. Now, it is evident that the pressures which take place on the rubbing parts of the engine, vary in proportion to the load it draws. That principle is true, provided the weight of the engine itself is taken as a part of the load. The only parts which are excepted from that rule are: the piston, which remains in all cases pressed in the same manner, the steam having no access into its interior; the slide, the friction of which varies with the pressure in the boiler, which depends only indirectly upon the load; and, lastly, the excentrics, the friction of which follows the friction of the slides. All the other parts of the engine are subject to the rule laid down above. The principal pressure takes place on the crank of the axle, and that pressure is exactly in proportion to the load.

There must consequently be a considerable difference in the friction of an engine when loaded or when without a load. We shall have recourse to experiments to determine that difference.

First, we shall endeavour to make ourselves acquainted with the friction of the engine without a load, and then we shall come back to the second part of the problem which consists in determining the influence of the load upon that friction. By that means we shall be able to calculate the resistance of locomotive engines in all circumstances.

§ 2. *Friction of the Engines determined by the least Pressure.*

The considerations above stated, which tend to prove that the power necessary to move an engine is very nearly the same, whether the force of the steam itself, or any other external agent, is employed, furnished us with two means of ascertaining the friction of engines without a load. The first consisted in seeking what was the least pressure of steam required by a locomotive engine to put itself in motion on the rails, when it had no other resistance than its own to overcome; the second was the method already employed in regard to the wagons. Both were successively tried.

The principle upon which the first of these two methods is founded is the following:—

If we find that the steam, by causing a known effective pressure per square inch, can make the engine advance, the area of the two pistons in square inches being known, it is easy to calculate the total force applied by the steam on those two pistons. That force being sufficient to make the engine advance,—that is to say, to conquer its resistance,—it gives of course the value of that resistance. It must only be observed according to the principle known in mechanics by the name of *the principle of virtual velocities*, that the pressure exercised on a part of an engine, being transmitted to another part of the same engine retains the same intensity only in case the two parts have the same velocity. If not, the force or pressure is reduced in an inverse ratio to the velocity of the points of application. This principle appears in an evident manner and *a priori*, in simple machines like the lever, the roll, the pully, &c. Inspection alone is sufficient to demonstrate, that if a force can, by the aid of the machine, raise a weight four times as great as itself, it is only by travelling, in the same space of time, four times as far as the weight it raises. In the case before us, the velocity of the piston is to that of the engine as twice the stroke is to the circumference of the wheel, the piston giving two strokes while the wheel turns once round. A force applied on the piston produces, therefore, in regard to the progress of the engine an effect reduced in the same proportion, that is to say, as twice the stroke is to the circumference of the wheel.

Let d be the diameter of the piston, and π the ratio of the circumference to the diameter, $\frac{1}{4} \pi d^2$ will be the area of one of the two pistons; and p being the *effective* pressure of the steam per square inch,

$$\frac{1}{2} \pi d^2 p$$

will be the *effective* pressure upon the two pistons. If, moreover, l express the length of the stroke, and D the diameter of the wheel, the effective force of transfer resulting for the engine, in consequence of that pressure, will be

$$\frac{1}{2} \pi d^2 p \times \frac{2l}{\pi D}, \text{ or } \frac{pld^2}{D},$$

which, according to what we have said, gives the measure of the resistance of the engine.

Here it must be noticed that we suppose the pressure of the steam in the cylinder to be equal to that in the boiler. The reason is, that in the experiments we shall have occasion to make, the motion of the engines being always extremely slow and the regulator completely open, the two pressures have time to put themselves in equilibrium, and are consequently equal. It must also be observed that the *effective* pressure p of the steam, or the surplus of the total pressure over that of the atmosphere, is not the true moving power residing in the steam. That moving power is the *total* pressure of the steam, which we shall express by P. But, on the other hand, the true resistance on the piston is neither that only which results from the traction of the engine. It comrpises also the atmospheric pressure, which takes place either directly or intermediately on the other face of the piston, as well as upon every other body in communication with the atmosphere. So, we omit on both sides an equal quantity, viz. the atmospheric pressure. Nothing prevents us here from simplifying in that manner; because having to compare the power and the resistance only in a case of equality, that equality is not destroyed by substracting an equal number on each side.

To succeed in ascertaining the least pressure by which the engine could be moved, it was necessary to take the engine at the instant when it furnished the steam at a very low degree of elasticity. In the evening, after the work was finished and the fire taken out of the fire-box, the water of the boiler began to lose its heat, and the steam that it generated also gradually lost its force. This was the proper moment to ascertain the least pressure by means of which the engines were able to advance on the rails. The spring-balance that shut the safety-valve enabled us to ascertain the pressure of the steam in the boiler, by loosening the spring until it stood in exact equilibrium with the pressure. It was then easy to calculate the pressure from the degree marked on the balance. However, to make all calculation unnecessary, the engine was brought to the mercurial gauge, which gave immediately the pressure per square inch in the boiler, at the moment of the experiment. It is in that manner that the following experiments were made:—

I. On the 5th of July, the ATLAS engine, cylinders 12 inches diameter, stroke 16 inches, weight 11.40 t., wheels five feet, four wheels coupled, was submitted to the experiment separated from its tender.

The spring of the balance having been successively loosened, to show the pres-

* According to the experiments of Coulomb on the resistance of surfaces.

sure of the steam in the boiler in proportion as it went down, the following trials were made :—

At 2 lbs. pressure, marked by the balance, the engine moved backwards and forwards, passing from a state of rest to one of motion, or conquering, besides the friction, what is called the *vis inertiæ* of the mass of the engine ; that is to say, not only maintaining an acquired velocity, but acquiring one which proves a surplus of force in the moving power.

At 1 lb. pressure, marked in the same way, the engine started, passing from a state of rest to one of motion.

The pressure diminishing a little more, the engine *continued* moving. At that moment we brought it under the mercurial gauge. It marked 4 lbs. effective pressure per square inch in the boiler, the valve then bearing no more than the weight of the lever, or a little less, which could not be ascertained, the balance not going below zero.

The cylinder being 12 inches in diameter, the area of the two pistons was 226 square inches. Thus a pressure of 4 lbs. per inch produced on the pistons a force of $226 \times 4 = 904$ lbs. that is to say, was able to move the resistance of 904 lbs. at the velocity of the piston. But at the velocity of the engine, which is greater in the proportion of the circumference of the wheel to twice the stroke, or $\frac{15.71}{2 \times 1.33} = 5.887$, that same force was only able to overcome a resistance of $\frac{904}{5.887} = 154$ lbs.

Thus, as we have seen that the engine continued moving at the moment it was brought under the steam gauge, though the pressure was then reduced to 4 lbs., we see that the resistance of the engine did not exceed 154 lbs.

This first experiment was made with the engine separate from its tender, with a view not to counteract one resistance by the other ; but, in wishing to apply it to lighter engines, of which the wheels were not coupled, a difficulty occurred. The pressure required for the engine to move without tender was so very low that the spring-balance could not mark it, that pressure being less than the weight of the lever itself. Another inconvenience of that low pressure was, that it could only be obtained at the moment the boiler generated no more steam at all ; the consequence of which was that at that moment the pressure diminished so rapidly that no confidence could be put in the accurracy of the experiment.

But as the resistance of the tender could be easily calculated by the experiments made on the friction of the carriages, and already inserted above, it was also easy to take it into account. Thus, by having the tender attached to the engine, the experiment presented the same degree of accurateness, with more facility in observing the pressure of the steam. It is for that reason that, in the following experiments, the tender was no longer separated from the engine :—

II. On July 21, the Sun engine, cylinders 11 inches, stroke 16 inches, weight 7.91 tons, wheels 5 feet ; only one pair of wheels worked by the piston, was submitted to the same experiment.

At 6 lbs. pressure by the balance, the engine started, followed by its tender full of coke and water.

At 4 lbs. the same.

At 2 lbs. the same.

At 1 lb. pressure the engine started also.

With the weight of the lever alone, the balance marking no pressure at all, the engine started again.

The pressure still a little further diminished, the engine did not start, but, once put in motion, continued going.

At that instant we brought it under the mercurial gauge ; it marked 5½ lbs. pressure per square inch, so that at that pressure the engine can move, followed by its tender.

The area of the two pistons (11 inches in diameter) being 190 square inches, a pressure of 5.5 lbs. per inch, produced on the piston a force of 190×5.5 lbs. $= 1{,}045$ lbs. at the velocity of the piston, and thus a draft of $\frac{1{,}045}{5.887} = 177.5$ lbs. at the velocity of the engine. That was then the force required to move the engine and its tender. Now, the tender filled with water and coke, weighed 6.50 tons, and according to the experiments made on the friction of the carriages, each ton required to put it in motion a power of 8 lbs. The tender consumed, therefore, for its share, a force of 6.50 lbs. $+ 8 = 52$ lbs. Thus the resistance proper to the engine was 177 lbs.—52 lbs. $= 125$ lbs.

III. On July 23, the same engine, the Sun, was tried again at the least pressure, and gave the following results :—

At 4 lbs. marked on the balance, the engine started, followed by its tender filled with water and coke.

At 1 lb. marked on the balance, it started rapidly.

At 0 of the balance, it still started with facility.

At 2 lbs. under zero, it still moved at the rate of two or 3 miles an hour.

At that instant it was put under the mercurial gauge, which marked 4¾ lbs. We may consider that, in this experiment, we had arrived at the lowest pressure by which the engine could move. According to the calculation established above, that pressure of 4¾ lbs gave a force of 902.5 lbs., which, referred to the motion of the engine, produced a traction of 153 lbs. Deducting 52 lbs for the resistance of the tender, there remained 101 lbs. for the resistance of the engine.

IV. The same day, the Firefly engine, cylinders 11 inches, stroke 18 inches, weight 8.74 tons, wheels 5 feet, one pair of wheels worked only by the piston, was submitted to the same trial.

At 3 lbs. marked on the balance, it started, followed by its tender filled with water and coke.

At 2 lbs, also,

At 0 it started also, came back, and went off again in a contrary direction.

At 1 lb, under 0, it still started forwards and backwards. The pressure diminishing a little more, the engine has just power enough to move.

At that moment it was brought to the mercurial gauge ; the pressure was found to be 4½ lbs. According to the proportions of the engine mentioned above, a pressure of 4½ lbs. per square inch on the piston, produced a traction on the engine of 163 lbs. ; deducting 52 lbs. for the tender, there remained for the proper resistance of the engine 111 lbs.

§ 3. *Friction of the Engines determined by the Dynamometer.*

While the resistance of the engines was being determined in that manner, other trials were also made, to obtain a valuation of that same resistance by means of the dynamometer.

V. On July 22, in the morning, the Vulcan engine, cylinders 11 in., stroke 16 in., wheels 5 ft., weight 8.34 t., one pair of wheels only worked by the piston, being ready to set off for Manchester, its boiler full of water, and its fire-box of coke, was separated from its tender. A circular spring-balance was fixed to the engine, and a lever was passed through the ring of the balance, so that two men might draw the engine by means of the lever.

The engine was first put in motion by five or six men. The first impulse being given, the two men that pushed on the lever maintained it without difficulty in motion, at the rate of two or three miles an hour. The index of the balance oscillated very much. It varied generally from 130 to 170 lbs., giving an average traction of of 150 lbs.

The balance was afterwards taken off from the front of the machine, and fixed behind on the Liverpool side, when the same experiment repeated, gave an aver age traction of 140 lbs. The index still oscillated about 20 lbs. above and below that point.

Average of the two experiments, 145 lbs.

The engine was ready to go off, and it had already made some turns on the rails, in order to light its fire and fill its boiler, so that the grease that anointed the rubbing parts was melted, and the oil perfectly liquid. But the experiment taking place in the interior of the Liverpool station, in a great thoroughfare, the rails were covered with cinders and dirt ; a circumstance which considerably augmented the resistance to the motion.

VI. On July 23, in the evening, the Sun engine, of which the proportions have already been givnn above, and the weight of which is 7.90 t., was tried in the same manner. It gave 100 lbs. traction towards Manchester, and 130 lbs. backwards, towards Liverpool. Average 115 lbs. The boiler of the engine was full of water ; the fire-box empty.

VII. On the same day, the Firefly, already described, the weight of which is 8.74 t., drawn by the dynamometer, required 125 lbs. in one direction, and 130 lbs. in the other. Average traction 127½ lbs. The boiler of the engine was full of water ; the fire-box was empty.

VIII. On the same day, the FURY engine, cylinders 11 in., stroke 16 in., wheels 5 ft., of which only one pair are worked by the piston, weight 8.20 t., required in advancing towards Manchester 100 lbs. traction, and 110 lbs. going back towards Liverpool. Average 105 lbs.

These experiments took place on the engines separated from their tenders. They were made on a part which is considered as being exactly level. We may, however, suppose, that on the precise spot where the engine was, the soil was not perfectly horizontal, and that that was the cause of the slight difference in the resistance, observed between one direction and the other.

§ 4. *Friction of the Engines calculated by the Angle of Friction.*

These results did not differ considerably from the preceding ones; but as in all the experiments, the index of the balance varied extremely, in consequence either of the slight inequalities of the road, or of the jerks given by the men that drew the engine, the average traction was very difficult to ascertain exactly. Besides, the dirtiness of the rails augmented considerably the resistance. It was, consequently, desirable to get those results verified by a different method, admitting of greater accuracy.

For that reason the same engines were submitted to experiments similar to those which had served to calculate the friction of the wagons.

IX. On July 30, the JUPITER engine, cylinders 11 in., stroke 16 in., wheels 5 ft., only one pair of wheels worked by the piston, weight 7.90 t., was brought on the inclined plane of Sutton, to the same place where the experiments on the friction of the wagons had been made. It was separated from its tender, and left to its gravity on the plane.

Gone off from the post No. 0, it continued its motion until 249 ft. beyond the post No. 18, and ran during 7′ 12″. This experiment gives: Distance travelled, 6189 ft.; difference in level between the points of departure and arrival, 36.78 ft.; consequently, friction $\frac{1}{168}$ of the weight, or $\frac{7.90\text{ t.}}{168.} = \frac{17{,}696\text{ lbs.}}{168} = 105$ lbs. This result includes the direct resistance of the air at a velocity of 9 to 10 miles an hour.

X. On July 31, the ATLAS engine, cylinders 12 in., stroke 16 in., wheels 5 ft., four wheels coupled, weight 11.40 t., was brought to the same place. Not having been in time, the train could not be stopped precisely at the suitable point, and the engine was already 99 ft. beyond the post No. 1. It was not possible to push back the considerable train it was drawing; so that the starting-point having been carefully determined, the engine was left to itself at that point, and ran to 273 ft. beyond the post No. 17.

The distance travelled by the engine was 5454 ft., and the difference in level between the points of departure and arrival, 32.07 ft. Thus the friction was $\frac{1}{170}$ of the weight, or 150 lbs. This calculation includes the direct resistance of the air, at an average velocity of 8 to 9 miles an hour.

XI. On August 1, the same engine, the ATLAS, brought to Sutton inclined plane, and the centre of the engine being carefully placed facing the usual starting-post, was left to its gravity on the plane. It ran until 45 ft. beyond the post No. 14.

Distance travelled in 5′ 40″, 4665 ft., total descent 35.40 ft.; friction $\frac{1}{131}$ of the weight, or 194 lbs.

The engine had been repaired the night before. The connecting-rods being too weak had been changed, and the new ones were not yet exactly adjusted to their proper length. The resistance they produced, acting upon the wheel at the end of a lever of one foot, which is the radius of the crank-arm by which they turn the wheel, produced the effect of a powerful brake to check the velocity of the engine. This friction of the ATLAS is, consequently, not applicable to the experiments made with that engine before August 1.

XII. On August 1, the VESTA engine, cylinders $11\frac{1}{8}$ in., (this engine had originally cylinders 11 in. diameter, but in repairing it, the cylinders were newly bored, which augmented their diameter by one-eighth of an inch,) stroke 16 in., wheels 5 ft., two wheels only worked by the pistons, weight 8.71 t., was submitted to the same trial. Setting off from post No. 0, it continued in motion to 33 ft. beyond post No. 11. It ran thus in 6′, over a space of 3663 ft., with a difference in level between the departure and the arrival of 33.07 ft.; which establishes the friction at $\frac{1}{164}$ of the weight, or 187 lbs.

This engine had been repaired, since which it had only made two or three trips at the time of the experiment. The different pieces were not yet well fitted, nor the joints very easy. Thence arose the increase of resistance observed in it, comparatively with the other engines.

XIII. On August 2, the FURY engine, cylinders 11 in., stroke 16 in., wheels 5 ft., not coupled, weight 8.20 t., left the usual starting-point, and stopped at 48 ft. beyond the post No. 18, running in 7′ over a space of 5,988 ft., with a difference of level between the points of departure and arrival of 36.68 ft.; which puts the friction at $\frac{1}{163}$ of the weight, or 113 lbs.

XIV. On August 2, the VULCAN engine, cylinders 11 in., stroke 16 in., wheels 5 ft., not coupled, weight 8.34 t., left to its gravtiy from a point situated at 27 ft. above the usual starting-point, ran in 6′ 30″ over a space of 5,391 ft. with a difference of level of 36.52 ft., which puts the friction at $\frac{1}{113}$ of the weight, or 127 lbs.

XV. On August 4, the LEEDS engine, having the same proportions as the FURY and the VULCAN, weight 7.07 t., ran in 6′ 30″ over a space of 5,472 ft., on a slope of 36.32 ft. Thus the friction of the engine was $\frac{1}{150}$ of its weight, or 105 lbs. (one of the pistons of the engine creaked for want of greasing.)

XVI. On August 15, the same engine, the LEEDS, went off from the same point, and ran over 5,061 ft. in 6′, on a slope of 35.86 ft., which puts the friction of this engine at $\frac{1}{141}$, or 112 lbs. (one of the pistons creaked, as in the foregoing experiment.)

All these results include the direct resistance of the air against the engine, at an average velocity of 10 to 12 miles an hour.

§ 5. *Table of the results of the foregoing Experiments on the Friction of Engines.*

Placing all those experiments next to each other, we form the following table:—

EXPERIMENTS ON THE FRICTON OF LOCOMOTIVE ENGINES.

Number of the experiment.	Date of the experiment.	Name of the engine.	Diameter of the cylinder.	Stroke of the piston.	Diameter of the wheel.	Weight of the engine.	Mode of determination.	Friction resulting from the experiment	Friction of the engine.	OBSERVATIONS.
	1834.		inches.	inches.	feet.	tons		lbs.	lbs.	
I -	July 5	Atlas .	12	16	5	11.40	by the least pressure	154	} 152	The engine has 6 wheels, 4 of which are worked by the piston.
X -	[illegible] 31	—	12	16	5	11.40	by the angle of friction	150		
XI -	Aug. 1	—	12	16	5	11.40	by the angle of friction	194	194	The connecting rods working hot.
II -	July 21	Sun . .	11	16	5	7.91	by the least pressure	125		
III -	July 23	—	11	16	5	7.91	by the least pressure	101	} 114	
VI -	July 23	—	11	16	5	7.91	by the dynamometer	115		
IV -	July 23	Firefly	11	18	5	8.74	by the least pressure	111	} 119	
VII -	July 23	—	11	18	5	8.74	by the dynamometer	127		
V -	July 22	Vulcan	11	16	5	8.34	by the dynamometer	145	} 136	
XIV -	Aug. 2	—	11	16	5	8.34	by the angle of friction	127		
VIII -	July 23	Fury . .	11	16	5	8.20	by the dynamometer	105	} 109	
XIII -	Aug. 2	—	11	16	5	8.20	by the angle of friction	113		
XV -	Aug. 4	Leeds .	11	16	5	7.07	by the angle of friction	105	} 108	
XVI -	Aug. 15	—	11	16	5	7.07	by the angle of friction	112		
IX -	July 30	Jupiter	11	16	5	7.90	by the angle of friction	105	105	
XII -	Aug. 1	Vesta .	11⅛	16	5	8.71	by the angle of friction	187	187	The engine rather stiff, having just come from repairing.

Considering these results, we see that, setting aside the VESTA, which was particularly circumstanced, the locomotive engines, with uncoupled wheels, had an average resistance of only 115 lbs.; and the ATLAS, with coupled wheels, and of a considerable weight, only 152 lbs., when not thwarted by his connecting-rods.

However, to provide a datum for all cases, it may be concluded from the total weight of the engines, compared with their friction, that locomotive engines, well constructed and in good order, have a resistance of 15 lbs. per ton of their weight. This is the result which may be reckoned upon, when an engine is not yet constructed, and when, consequently, one can estimate only by guess what will be its future friction.

We have already observed, that the experiments with the dynamometer and by the least pressure, were made on a spot where the rails offered more resistance than along the line. On the other hand, the experiments on the angle of friction took place at a point of the railway where there were nine crossings to get over. These obstacles acted more particularly on the engines, because they occurred in a place where the velocity of the motion was already considerably dimmished. We may, therefore, when we have engines well constructed, kept in good repair, and on the Liverpool model, calculate on the result we have obtained, without fear of putting the resistance too low.

In each of the experiments with the engines, which we shall have occasion to relate, we shall take not the average result, but the individual friction of each of them, as it has been determined.

ARTICLE II.

OF THE ADDITIONAL FRICTION OF LOCOMOTIVE ENGINES, IN PROPORTION TO THE LOAD THEY DRAW.

§ 1. *Of the Mode of Calculation.*

We have now determined the friction or resistance of locomotive engines, when they draw no load. We have, however, already shown, that the friction must increase in proportion to the load the engine draws. The aim of our researches must, therefore, now be, to discover the amount of friction for different loads, in order to deduce from it the surplus of resistance created in the engine by each ton of the load.

When an engine executes the traction of a train, we know the pressure in the boiler by inspecting the spring-balance; but we do not know the pressure of the steam in the cylinder, because, in passing from the boiler to the cylinder, the elastic force of the steam changes, as will be seen hereafter. If we could know, *a priori*, the pressure in the cylinder; if, for instance, it were possible to apply a mercurial guage to it, we might immediately deduce the friction of the engine corresponding to that load.

In fact, if by hypothesis we know the pressure in the cylinder, or on the piston, by calculating the total effect of that pressure on the area of the piston, we find the exact valuation of the power applied by the engine,

On the other hand, we also know the resistance opposed to the motion; it being composed of the resistance of the train and of the engine.

Besides, if the engine, in drawing that load, increased constantly in velocity, it is clear that there would be an excess of power over the resistance. If, on the contrary, the velocity were to diminish gradually, the power would be inferior to the resistance; but if we take the engine at the moment it has acquired a certain uniform velocity, and if that velocity be maintained without alteration, the power the engine thus applies must necessarily be exactly equal to the resistance it undergoes, or else there would be either acceleration or retardation in the motion.

Thus we know the power applied by the engine; we know the resistance to the motion, which is the sum of the resistance of the train and that of the engine; and, besides, this sum is equal to the power applied: consequently, the resistance of the engine is equal to the power applied, less the resistance of the train.

This mode would give thus immediately the friction of the engine, if we knew the pressure in the cylinder.

But there are cases in which the pressure in the cylinder is known *a priori*, and is equal to the pressure in the boiler. These cases are those in which the engine attains the limit of its power with the pressure at which it is working; that is to say, when it

draws the greatest load it can draw with that pressure.

In fact, as by the hypothesis the engine has arrived at the limit of its power, the pressure in the cylinder cannot be less than in the boiler; for, if it were, by diminishing the velocity, which is the only obstacle to the establishment of an equilibrium of pressure between the two vessels, one might give to the steam time to rise in the cylinder until it would equal the pressure in the boiler, and then the effect would be augmented. That is to say, that the engine might draw a greater load, provided its velocity were diminished. On the contrary, as soon as the pressure in the cylinder becomes equal to that in the boiler, there is no further diminution of velocity that will permit to increase the load; for an increase of load requires an increase of moving power, which is no longer possible.

Thus, in case one has attained the *maximum* load of the engine, the power applied is known *a priori*; and one may, as we have actually done above, deduce from it the corresponding friction of the engine.

Let us then suppose, that in an experiment we have attained the limit of the power of the engine. Let d be the diameter of the piston, and π the ratio of the circumference to the diameter, $\frac{1}{4}\pi d^2$ will be the area of the piston, and $\frac{1}{2}\pi d^2$ the area of the two pistons together. Let also p be the effective pressure per unit of surface of the steam in the boiler, such as it has been observed during the experiment; it is clear from what we have said above, that $\frac{1}{2}\pi d^2 p$ is the force then applied to the piston.

Calling D the diameter of the wheel, and l the length of the stroke, the force applied to the piston is, when transferred to the engine, reduced in proportion to their respective velocities, or in the proportion of $\frac{2l}{\pi D}$. Thus, after its transfer to the engine, it is expressed by

$$\tfrac{1}{2}\pi d^2 p \times \frac{2l}{\pi D} = \frac{pd^2 l}{D},$$

which is the expression of the power of traction as applied to the progress of the engine.

On the other hand, M being the weight of the load, expressed in tons, and n representing the resistance for each ton of the load, such as we have determined it in the preceding chapter, nM is the resistance of the train. Finally, if we represent by X the proper resistance or frictien of the engine,

$$n\mathrm{M} + \mathrm{X}$$

will be the total resistance offered to the motion of the engine.

Having seen that, when the motion is uniform, the power applied by the engine is equal to the resistance, we have

$$\frac{pd^2 l}{D} = n\mathrm{M} + \mathrm{X};$$

and finally,

$$\mathrm{X} = \frac{pd^2 l}{D} - n\mathrm{M},$$

which equation gives us the value we sought of the friction of the engine.

In this equation p is the effective pressure in lbs. per square inch in the boiler; d the diameter of the piston expressed in inches; l the length of the stroke; and D the diameter of the wheel, both expressed either in inches or in feet, which is indifferent, the equation containing only their ratio. The number n, which is the resistance per ton, is 8 lbs.; and thus the value of X, when found, will also be expressed in lbs.

Here, as well as in the experiments made above with engines without load, we do not, in calculating the resistance, take into account the atmospheric pressure; because, also, in calculating the power, instead of reckoning the *total* pressure of the steam, we only reckon its surplus above the pressure of the atmosphere. In doing this, we only suppress on each side two equal forces which equilibrate. Having here, as before, only to compare the power and the resistance in a case of equality, the substraction of an equal quantity can take place on both sides without altering the result.

The formulæ we have obtained is very simple, and the principle it represents will easily give us the resistance of the engine, in all the cases in which it has attained the limit of its power. All that remains to be done, is therefore to arrive at tha point.

In consequence, experiments were made in that view, sometimes taking the greatest loads the engine was able to draw, and at others only middling loads, but lowering the pressure, by means of the spring-balance, as much as possible, without stopping the train.

Those experiments were made on three inclined planes of the Liverpool and Manchester Railway; viz. Sutton plane inclined at $\frac{1}{89}$; Whiston plane inclined at $\frac{1}{98}$; and the rise of Chatmoss at $\frac{1}{1760}$.* In estimating the resistance on these planes it is clear that the gravity of the mass, decomposed along the plane, forms an additional resistance to the friction of the carriages; so that the resistance of the train, not including the friction of the engine, is then composed of the friction of the wagons, at the rate of 8 lbs. per ton, and moreover of the gravity of the total mass in motion on the plane. Thus a train of 40 t., drawn by an engine weighing 10 t., offers on Sutton inclined plane the following resistance:—

	lbs.
40×8 lbs. = 320 lbs. friction of the carriages at 8 lbs. per ton, . . .	320
$\frac{40 \times 2240 \text{ lbs.}}{89}$ = 1,006 lbs. gravity of the 40 t. (reduced in lbs.) on a plane inclined in the ratio of $\frac{1}{89}$,	1,006
$\frac{10 \times 2240 \text{ lbs.}}{89}$ = 251.6 lbs. gravity of the engine on the same plane, . .	252
Total resistance, not including the friction of the engine, ...	1,578

And as we know that on a dead level a ton only requires 8 lbs. traction, we see that the train going up the plane is equal in that circumstance to a load, on a dead level, of $\frac{1578}{8} \times 197\frac{1}{4}$ t.

This is the manner in which the calculation will be made in the following experiments.

We give a considerable number of experiments because having to apply to the wagons their average resistance per ton, the greater the number of carriages, the more accurate will be the calculation.

§ 2. *Experiments on the additional Friction of Engines.*

I. On July 22, 1834, the VULCAN engine, cylinders 11 in., stroke 16 in., wheels 5 ft., weight 8.34 t., ascended *Sutton* inclined plane with a first-class train of nine carriages, amongst which the mail and two empty trucks; weight of the train, tender included, 39.07 t.

The velocity of 26.6 miles, before arriving at the plane, settled at the rate of 20 miles an hour for the first half of the ascent, took then an average of 11.42 miles, and went down to 7.5 miles in the last quarter of a mile of the ascent, which is a little steeper than the rest.

The spring-balance of the engine, fixed at 31, as a point of departure, marked 36, which by the mercurial gauge corresponds to 57.5 lbs. effective pressure per square inch.

In consequence of the proportions of that engine, we have:

190 area of the two cylinders in square inches, multiplied by
57.5 lbs. pressure of the steam per square inch in the boiler or on the piston, makes
10,925 lbs. force applied on the piston; which being transferred as a power of traction to the engine, the velocity of which is 5.887 times greater, gives

$\frac{10{,}925}{5.887}$ lbs. = 1856 lbs. power applied to make the engine advance.

On the other hand, the resistance was

39.07×8 lbs. =.....313 lbs. resistance, owing to the friction of the carriages.

$\frac{47.41 \times 2240 \text{ lbs.}}{89}$ = 1193 resistance owing to the gravity of the total mass, train and engine.

1506 total resistance.

Thus:

1,856 lbs. power applied.
—1,506 resistance, equal to 168¼ t. on a level.

350 corresponding friction of the engine.

As we have said, the average velocity of the ascent was 11.42 miles per hour, and the velocity at the top of the plane 7.5 miles per hour.

In all the experiments we give those two velocities separately, because the engine having a great impulse on arriving at the plane, we wish as much as possible to disengage that acquired velocity from the velocity proper to the motion. If we were to

* See the Section of the Liverpool Railway, Chap. V., Art. VII., § 1.

take 11.42 miles as the velocity of the motion, it would be a little too much, being complicated with the first impulse. On the other hand, by taking 7.5 miles we should commit a contrary error, because the last quarter of a mile of the ascent is steeper than the rest, and surpasses the inclination of $\frac{1}{89}$, on which our calculation is founded.

They call the first-class trains those which carry travellers, and go from Liverpool to Manchester without stopping. The carriages of those trains are never weighed. In all the experiments we have calculated them at an average weight of 4.73 t. loaded, and the mail coach at 3.44 t. The tender is reckoned at the rate of 5 t., or 5.50 t. according to the quantity of water and coke it contains at the moment of the experiment. The weight of the wagons, whether empty or loaded, is taken *exactly* in tons, cwts., quarters, and pounds. To simplify we shall express it here in tons and decimal fractions of tons.

II. On July 22, 1834, the same engine, the VULCAN, ascended *Whiston* inclined plane with a first-class train of 9 carriages, amongst which were the mail and two loaded trucks; weight of the train, tender included, 41.32 t. The velocity remained uniform during the ascent at 18.75 miles an hour, diminishing only to 12 miles an hour on the last quarter of a mile. The balance fixed at 31 marked 36, or effective pressure by the mercurial gauge 57.5 lbs. per square inch in the boiler.

This experiment gives:

lbs.
1,856 power.
1,489 resistance, equal to 186 t. on a level.

367 corresponding friction of the engine.

III. On July 23, 1834, the ATLAS, cylinders 12 in., stroke 16 in., wheels 5 ft., weight 11.40 t., balance fixed at 50 lbs. as a point of departure, started from Liverpool with a train of 40 wagons weighing exactly 190 t., and, including the tender, 195.50 t.

The help of two other engines was necessary for the moment of starting. On *Whiston* inclined plane the train was helped by four engines; viz. two in front of the train, the AJAX and the EXPERIMENT, and two behind, the SUN and the GOLIATH. Drawn thus by five locomotive engines, the train went up the plane without a moment's delay; and once at the top, the ATLAS resumed alone the haulage.

Arrived at the rise of *Chatmoss*, the engine with its whole train, ascended it without help for a space of 5½ miles. Its velocity was however considerably reduced. The first six quarters of a mile were travelled with an uniform velocity of 15 miles an hour, pressure 51 by balance, or 54 lbs. by the mercurial-gauge. During the four following quarters the velocity was 10 miles an hour, same pressure. Here began a steeper ascent for half a mile. At this point the velocity decreased rapidly. During the first quarter of a mile it fell from 10 miles to 6 miles an hour; during the second it fell to 3½ miles, and continued diminishing to the end of the pass. In proportion as the velocity diminished the pressure rose; first to 51½, then to 52 by the balance, where it stopped, pressure corresponding with 55 lbs. by the mercurial-gauge. After the passage of the obstacle the velocity increased again to 4½ miles, then to 7½ miles an hour; after which it settled again for the rest of the ascent at its regular rate of 15 miles an hour. At the same time the pressure went down again to 51 by the balance, or 54 lbs. by the mercurial-gauge.

At passing a second similar irregularity of short duration, near the bridge on the Bridgewater Canal, the same effects were produced. The velocity was again reduced to 3½ miles, and the pressure rose again to 52 by the balance.

The irregularity which exists on Chatmoss is an inclined plane rising at the rate of 8 feet per mile, or $\frac{1}{660}$, and the other parts of the moss have a much smaller inclination, so that the average inclination is no more than $\frac{1}{1760}$; but the difficult pass is only half a mile long. When a mass of 200 t. arrives with a velocity of 15 miles an hour, and has consequently a considerable momentum, an obstable, the inclination of which is moderate, and lasts only for half a mile, cannot completely destroy the first impulse. The engine not having been able, during its passage over the obstacle, to acquire an uniform velocity, but continuing on the contrary, to the last moment, to lose some of its speed, showed that that obstacle was too much for it; but the fact, ascertained on a length of 5½ miles, proved that the average inclination of the ascent, or $\frac{1}{1300}$, was within the limits of its power, with a pressure of 55 lbs. per square inch.

This experiment having given rise to some doubts on the real proportions of the ATLAS, we measured them ourselves a few days afterwards, on August 8, 1834, when the engine was under repair, and they were found perfectly exact. The diameter of the cylinder is 12 in.; the stroke, measured on the crank of the axletree then separated from the engine, 16 in.; wheels 5 ft., at the part that rests on the rail, with three-eighths of an inch more near the flange, and the three-eights less at the basiled part.

This experiment, taken on the irregularity of Chatmoss, gives:

lbs.
2,111 power of the engine.
2,226 resistance opposed by the load on the accidental slope at $\frac{1}{660}$.

—155 power minus.

The resistance exceeded the power. It was consequently really impossible for the engine to settle at an uniform velocity, during its passage over the obstacle. It was necessarily compelled to lose constantly of its speed, and would have stopped if the obstacle had lasted any longer.

But, taken on the average rise at $\frac{1}{1300}$, we have:

lbs.
2,111 power.
1,921 resistance of the train, equal to 240 t. on a level.

190 corresponding friction of the engine.

The average velocity during the experiment was 8 miles an hour; the least velocity 3½ miles an hour.

IV. The same engine, on the same day, travelling with the same train over *Rainhill* flat, which is a dead level, attained an uniform velocity of 9.23 miles an hour; the balance fixed at 50 marked 50.5, or effective pressure 53.5 lbs. by the mercurial-gauge.

lbs.
2,054 power.
1,564 resistance of the train, equal to 195½ t. on a level.

490 corresponding friction of the engine.

V. On July 23, 1834, the same engine, the ATLAS, ascended *Sutton* with a part of its train, consisting of 8 wagons, weighing 33.90 t. besides tender, and 39.40 t., tender included; balance fixed at 50 and marking 52, or effective pressure 55 lbs.; velocity 6 miles an hour.

lbs.
2,111 power.
1,594 resistance, equal to 199¼ t. on a level.

517 corresponding friction of the engine.

VI. On July 24, 1834, the FURY, cylinders 11 in., stroke 16 in., wheels 5 ft, weight 8.20 t., ascended *Whiston* with a train of 10 wagons, weighing together 51.16 t., and 56.16 t. with the tender; balance fixed at 32 and marking 35, or effective pressure by the mercurial-gauge 65½ lbs. per square inch in the boiler; average velocity 6.31 miles an hour, reduced to 3.33 miles at the top of the plane.

lbs.
2,114 power.
1,951 resistance, equal to 244 t. on a level.

163 corresponding friction of the engine.

VII. On July 24, 1834, the same engine, the FURY, ascended *Sutton* with a train of 10 wagons weighing 43.80 t., and 48.80 t. including the tender; balance fixed at 32 and marking 36, or effective pressure 67 lbs.; velocity 15 miles an hour. The engine drew its train with evident ease.

lbs.
2,162 pewer.
1,825 resistance, equal to 228 t. on a level.

337 corresponding friction of the engine.

VIII. On July 31, 1834, the ATLAS, of which the proportions have already been given, cannot ascend *Whitson* with a load of 14 wagons weighing 61.65 t., and 67.15 t. tender included, though the balance had been carried to 57, as point of departure, and marked 60, or effective pressure 63 lbs. per square inch in the boiler.

lbs.
2,419 power.
2,370 resistance, equal to 296¼ t. on a level.

39 surplus of the power over the resistance, not sufficient to overcome the friction of the engine.

IX. On July 31, the same engine, the ATLAS, cannot ascend *Sutton* with a train of 8 wagons loaded and 4 empty, weighing 35.15 t., and 40.15 t. tender included. The balance had been purposely lowered to 40, as point of departure, and marked 42½, or effective pressure by the mercurial-gauge 46 lbs. per square inch. The velocity from 20 miles an hour, as it was before arriving at the plane, fell immediately to 7½ miles in the first quarter of a mile; in the second quarter it fell to 4¼ miles; in the third to 2¼ miles, and at last the engine stopped.

lbs.
1,766 power.
1,619 resistance, equal to 202⅓ t. on a level.

147 surplus of power over the resistance, not sufficient, as we see, to overcome the friction of the engine. We have seen that the friction of this engine, even without a load, is 152 lbs.

X. At the conclusion of the latter experiment, and just at the moment when the engine stopped, the balance was raised to 45, and marked 47½, or effective pressure by the mercurial-gauge 51 lbs. With that pressure the engine regained velocity by degrees, and attained an uniform velocity of 7½ miles an hour, with which it reached the top.

lbs.
1,958 power.
1,619 resistance, equal to 202⅓ t. on a level.

339 corresponding friction of the engine.

XI. On August 1, 1834, the VESTA, cylinders 11⅛ in. (this engine had originally cylinders of 11 in., but, in repairing them, they were bored again and acquired a diameter of 11⅛ in.,) stroke 16 in., wheels 5 ft., weight 8.71 t., with a train of 10 wagons weighing 43.72 t, and 49.22 t. tender included, ascended *Whiston* until within 60 yards of the top. There the engine was on the point of stopping, and several men were obliged to push very hard at the wheels in order to enable it to attain the summit. Balance fixed at 20½, and marking 23½, or effective pressure by the mercurial-gauge 58 lbs. per square inch. The velocity of 20 miles per hour for the first four quarters of a mile of the inclined plane, was reduced to 10 miles for the fifth quarter, and to 6 miles for the following one; afterwards the speed fell completely, on arriving at the steep part that exists towards the top of the inclined plane. This steep part must however be ascended, before it can be said that the engine has gone up the plane; for the average inclination calculated at ¹⁄₇₅, comprises equally that part, and if we were to separate it from the remainder of the plane, that remainder would have a less inclination than ¹⁄₈₀: consequently, the load was too much for the engine with that pressure.

lbs.
1,915 power.
1,746 resistance, equal to 218⅜ t. on a level.

166 surplus of the power over the resistance, insufficient to overcome the friction of the engine. We have seen that the friction of this engine, even without any load, amounts to 187 lbs.

XII. On August 4, 1834, the ATLAS, of which the proportions have already been given, with a train of 9 loaded wagons and 7 empty ones, weighing together 38.76 t., and with the tender 44.26 t., could not ascend *Sutton*; the balance being fixed at 55, and marking 57½, or effective pressure 60½ lbs. per square inch in the boiler. That pressure is not sufficient; the engine is ready to stop.

lbs.
2,323 power.
1,755 resistance, equal to 219½ t. on a level.

568 surplus of the power over the resistance, insufficient to overcome the friction of the engine.

This experiment and the following one confine the friction of the engine within very narrow limits; that is to say, between 568 lbs. and 616 lbs., and seem to raise that friction very high; but in referring to experiment No. XI, on the friction of the engines without load, we see that at the time those two experiments were made, the engine had been newly repaired, and was not yet working satisfactorily. On August 1, its resistance, without load, had been found to be 194 lbs., instead of 152 lbs., that it was before, a circumstance which we attributed then to the connecting-rods not being properly adjusted; but the defect seems however to have been more vital, and to have rather continued to increase, as, on August 7, the axle of the engine broke.

XIII. At the conclusion of the foregoing experiment, just at the moment the engine was going to stop, the pressure was raised, by means of the spring, to 58¾ by the balance, or 61¾ lbs. effective pressure per square inch in the boiler by the mercurial gauge. With that pressure the ascent was concluded, with a speed of 3.75 miles an hour for the upper part of the plane.

lbs.
2,371 power.
1,755 resistance, equal to 219⅓ tons on a level.

616 corresponding friction of the engine.

XIV. On August 4, 1834, the FURY, cylinders 11 in., stroke 16 in., wheels 5 ft., weight 8.20 t., ascended *Sutton* with a first-class train of 8 carriages, amongst which was an empty truck; weight of the train 32.97 t., and with the tender 37.97 t.; pressure purposely reduced to 33 lbs. by the balance, or 55 lbs. by the mercurial-gauge. Average velocity 13.33 miles, *minimum* velocity 10 miles an hour at the top of the plane.

lbs.
1,775 power.
1,466 resistance, equal to 183¼ tons on a level.

309 corresponding friction of the engine.

XV. On August 15, the LEEDS, cylinders 11 in., stroke 16 in., wheels 5 ft., weight 7.07 t., ascended *Sutton* with 7 wagons, weighing 29.65 t., and tender included 35.15 t. The pressure purposely reduced, stood at 29 by the balance, or 48.5 lbs. by the mercurial-gauge. The velocity of 15 miles an hour for the first mile of the ascent fell to 10 miles for the following quarter, and to 6.6 miles for the last quarter of a mile near the top; average velocity 10 miles.

lbs.
1,565 power.
1,344 resistance, equal to 168 t. on a level.

221 corresponding friction of the engine.

XVI. On August 16, 1834, in the morning, the VESTA, the proportions of which have already been given, ascended *Sutton* with a train of 7 loaded wagons, weighing together 34.43 t., and 39.93 t., tender included; the valve fixed at 20 as a point of departure, on the balance, and blowing at 23¼, or effective pressure per square inch by the mercurial-gauge 57.25 lbs. Velocity at the top of the plane, 2.50 miles: (The engine had set off on the plane without impulse or acquired velocity.)

lbs.
1,891 power.
1,543 resistance, equal to 193 t. on a level.

348 corresponding friction of the engine.

XVII. On August 16, 1834, in the morning, the same engine ascended *Sutton* with 8 wagons, weighing 31.95 t., and 37.45 t., tender included; balance fixed at 20, as point of departure, and marking 23¼, or effective pressure 58 lbs. per square inch in the boiler by the mercurial-gauge. *Minimum* velocity at the moment of attaining the summit of the plane, 3.25 miles.

lbs.
1,915 power.
1,462 resistance, equal to 182¾ tons on a level.

453 corresponding friction of the engine.

XVIII. On August 16, in the evening, the same engine, the VESTA, ascended *Sutton* with 8 loaded wagons, weighing 27.05 t., and 4 empty ones, weighing together 7 t., more, the tender making altogether 69.05 t.

Balance fixed at 20 lbs. and marking 23 lbs., or effective pressure per inch 56.5 lbs. by the mercurial-guage. Velocity at the most difficult point of the ascent, 17 complete strokes of the piston per minute, or 3 miles an hour.

lbs.
1,866 power.
1,514 resistance, equal to 189 tons on a level.

352 corresponding friction of the engine.

§ 3. *Table of the Results obtained on the additional Friction of Engines.*

If, amongst the foregoing experiments, we bring together those that have produced results, we get the following table. We have placed in it only those experiments, the velocity of which was not considerable. It is, indeed, clear that the more the velocity was reduced, the nearer the engine was to attain the proposed end, that is to say, to arrive at the *maximum* load it could possibly draw with its pressure :—

EXPERIMENTS ON THE FRICTION OF LOADED LOCOMOTIVE ENGINES.

Number of the experiment.	DATE.	Name of the engine.	Diameter of the cylinder.	Stroke of the piston.	Diameter of the wheel.	Weight of the engine.	Friction without any load.	Effective pressure in the experiment.	Velocity of the experiment.	Load on a level.	Corresponding friction of the engine.	OBSERVATIONS.
			inches.	inches.	feet.	tons.	lbs.	lbs. per square inch.	miles an hour.	tons.	lbs.	
I - -	1834. July 22	Vulcan	11	16	5	8.34	136	57.5	7.50	188	350	
II - -	July 22	—	11	16	5	8.34	136	57.5	12.00	186	367	
VI - -	July 24	Fury	11	16	5	8.20	109	65.5	3.33	244	163	
XIV -	Aug. 4	—	11	16	5	8.20	109	55.0	10.00	183	309	
XV - -	Aug. 15	Leeds	11	16	5	7.07	108	48.5	6.60	168	221	
XVI -	Aug. 16	Vesta	11 1/8	16	5	8.71	187	57.25	2.50	193	348	
XVII -	Aug. 16	—	11 1/8	16	5	8.71	187	58.0	3.25	183	453	
XVIII -	Aug. 16	—	11 1/8	16	5	8.71	187	56.5	3.00	189	352	
III - -	July 23	Atlas	12	16	5	11.40	152	55.0	3.50	240	190	
IV - -	July 23	—	12	16	5	11.40	152	53.5	9.23	196	490	
V - -	July 23	—	12	16	5	11.40	152	55.0	6.00	199	517	
X - -	July 31	—	12	16	5	11.40	152	51.0	7.50	202	339	
XIII -	Aug. 4	—	12	16	5	11.40	194	61.75	3.75	219	616	The connecting-rods keyed too tight.
		Mean	...	...	...	...	151			-200	362	

Considering the average friction deduced from these experiments, we see that a load of 200 t. causes in the engine, above its proper resistance, an *additional* friction of 362 lbs. 151 lbs. = 211 lbs.; which makes 1.05 lbs., or about 1 lb. per ton.

§ 4. *New Illustration of the Mode of Calculation employed.*

The friction of the engines must be increased by the load; for it is a principle in statics, easy to be ascertained in a simple machine like the lever, the pulley, the winch, &c., that for two forces to equilibrate on that machine, the fixed axis, plane or fulcrum, must support the resulting effort of the two forces. Thus the pressure on the fulcrum is in ratio to that resulting force. If the machine be in motion, we have seen that, as soon as that motion becomes uniform, the power equilibrates exactly the resistance, or the machine falls into the preceding case. Thus again, the pressure on the fixed points is in proportion to the forces that equilibrate on the machine. Consequently, the friction follows the same rule, being itself in proportion to the pressure.

This is applicable to the friction on all the joints of an engine, and consequently to what we call its resistance, which is nothing else than the aggregate of all those frictions.

An increase of resistance, in proportion to the load, is therefore founded on principle, and the mode of calculation we have employed must give us its exact measure. It is sufficient for it that the engine have really attained the limit of its power with a given pressure; that is to say, the *maximum* load it is able to draw with that pressure. In those cases in which the engine reduced its velocity to the rate of two or three miles an hour, it was evident that that point was attained, as the engine was literally going to stop. But besides, we shall see that in all the cases where the velocity did not exceed 12 miles an hour, we were authorised also to consider the pressure on the piston as equal to that in the boiler.

In fact, the steam being at a certain degree of pressure in the boiler, passes into a narrow steam-pipe, and from thence into the cylinder, where it immediatety dilates, and would quickly attain the same degree of pressure as in the boiler if the piston was immoveable. However, the piston opposing on the contrary only a limited resistance, determined by the load drawn by the engine, 40 lbs. per square inch for instance, will obey as soon as the elastic force of the steam in the cylinder will have attained that point. A piston which only bears a resistance of 40 lbs. per square inch, is nothing but a valve loaded with 40 lbs. per square inch. If the communication between the boiler and the cylinder were completely free, and without pipe or narrow passage, the piston would become a real valve for the boiler; and that valve giving way before the safety valve, which is loaded, for instance, with 50 lbs. per square inch, the steam in the boiler could not rise above 40 lbs. The passage, however, being narrowed, the piston is not a valve for the boiler, but it remains one for the cylinder.

From this result three points. 1st. That the pressure in the cylinder is exactly equal to the resistance on the piston. 2nd. That it is because the piston yields and gives way to the steam that the steam cannot augment its pressure beyond that point, nor

rise to the pressure in the boiler; but that if by any means the piston could be rendered immoveable, or only if it were not to give way quicker than the steam is generated, the equilibrium of pressure would immediately be established between the cylinder and the boiler; and, 3d., that if, in the steam-pipe, the velocity of the current is greater than the one corresponding to the generation of the steam in the boiler, it is because the pressure is less in the cylinder than in the boiler, and that in consequence the fluid endeavours to put itself in equilibrium in the two vessels; without which there could only be the current, owing to the generation of the steam.

From these observations, we see that the effective pressure on the piston may be calculated after that which exists in the boiler, as soon as the velocity of the piston is reduced to an equality with that of the generation of the steam. As we shall soon know by experience what is the total mass of steam, at the pressure of the boiler, generated by the engine in a given instant, it will be easy to calculate how many cylinders full of steam, at that pressure, the engine is able to furnish in a minute, and thus what is the velocity that corresponds to what we call full pressure in the cylinders. We shall then find, that for the engines we are examining, that velocity is at least twelve miles an hour. Thus we may consider that in all the cases in which the velocity did not exceed that rate, the pressure in the cylinder was the same as in the boiler, and, consequently, that in reckoning it in that proportion, we had the exact measure of the power then applied by the engine.

CHAPTER V.

GENERAL THEORY OF THE MOTION OF LOCOMOTIVE ENGINES.

ARTICLE I.

OF THE VELOCITY OF THE PISTON.

In endeavouring to calculate the effect of steam engines, that is to say, the velocity of the piston under a given load, the calculations have until now rested on two *data*, the pressure of the steam in the boiler and the resistance of the load on the piston; one being considered as representing the power exercised by the engine, and the other the resistance opposed by the load.

This mode appears exact at first sight, and seems to embrace all the *data* of the problem; but the mistake committed in that respect ought to have been discovered, since every formulæ obtained in that way is easily demonstrated false by experience.

It is particularly when we wish to apply that mode or those formulæ to that motion of locomotive engines, in order to calculate what load they are able to draw at a given velocity, or what velocity they will acquire with a given load, that we discover the formulæ give no rational result.

The cause thereof resides in the following fact, viz. that the pressure of steam in the boiler is by no means the *complete* expression of the power of the engine. It only indicates that power for a determined instant. It is indeed sufficient whenever it is required to compare the effort applied with the effect produced, during a very short instant, or in a case of equilibrium; but as soon as we have a continuation of motion, the pressure in the boiler is no longer sufficient to represent the power of the engine. This is nothing more than what is observed continually in mechanics. In a case of equilibrium, the measure of a force is the mass with which it equilibrates; but in a case of motion, the force is represented not only by the mass it sets in motion, but also by the velocity it is able to impart to that mass. In other words, the force is represented by its own intensity added to the velocity with which it is able to keep up that intensity. The same thing occurs here. The pressure in the boiler indicates the mass with which the engine can equilibrate; but it is the velocity of generation of the steam that indicates the motion the engine is able to impart to that mass.

It is, in fact, evident that the power of the engine resides at the same time, both in the greater or smaller quantity of steam generated, and in the degree of pressure or elastic force of that steam. The power consists thus in the quantity of water the engine is able to transform into steam in a given time, for instance in a minute, which we shall call the evaporating power of the engine, and in the degree of pressure of the steam.

In that valuation we see that the pressure is only the means by which to ascertain the state or intenseness of the power, at the moment its quantity is measured; and this explains the reason why, when the motion is not to last, and that in consequence the quantity need not be considered, the pressure is sufficient to represent the power. But this is not the case in a continued motion.

When an experiment is to be made with an engine, however weak it may be in regard to evaporating power, it will be easy, by charging the valve with 50 lbs. per square inch, to fill the boiler with steam at that effective pressure. If then we attach to the engine a load of 100 t. which would produce, by supposition, on the piston, a resistance of 46 lbs. per square inch, atmospheric pressure included; shall we say that the engine must necessarily draw that load with a certain fixed speed, which will only depend on the pressure of steam in the boiler and the resistance on the piston? No, assuredly. For if it should happen that the engine transform in a minute a cubic foot of water into steam at the pressure of the boiler, it may by that evaporation suffice to produce a certain speed; but if, all things remaining the same, it only evaporates half the quantity, it is clear that it will only be able to fill the cylinder half as many times in a minutes, and that consequently the pressure in the boiler may remain strictly the same, whilst the speed of the engine with the same load will necessarily be reduced to one half. We see, thus, that neither the pressure in the boiler, nor the supposition that that pressure be maintained in the same state in the different cases of motion, are sufficient to represent completely the power of the engine.

It is thus the evaporation of which the engine is capable that rules its effect, and which must consequently give us the measure of that effect.

If, by analogy with other boilers already tried, and by a comparison of the extent of the heating surfaces, we calculate beforehand what mass of steam a boiler is able to generate in a minute, at a given pressure, we shall then begin to get an idea of the power of which it disposes, and which the engine is able to carry into action.

If, better still, we fill the boiler with water, and produce by some manner or other, in the fire place, a fire as intense as it generally is when the engine is at work, so that we may thus ascertain its evaporating power, then only shall we know what the engine, to which we may join that boiler, will be able to execute in a given time.

The pressure in the boiler, taken by itself, can only solve one of the questions we have to consider: that is to say, the greatest load the engine is able to draw, on account of the necessity which exists that the resistance on the piston should never exceed the pressure in the boiler, as in that case the resistance would be greater than the moving power and no motion would be generated. But, that one case excepted, we must necessarily have recourse to the evaporating power, the pressure being only one of the elements of the force which is to be computed. The separate influence of each of those two elements in the result is as follows:—

The greatest possible load is marked by the degree of pressure in the boiler.

And the greatest speed with that load, or with any other, is given by the evaporating power.

It is therefore by employing both these elements that we shall be able to solve the question.

With that view we shall successively consider three different points.

The resistance produced on the piston by a given load;

The pressure of the steam in the cylinder in consequence of that resistance;

And, finally, the determination, by experiments of the evaporating power of the engines.

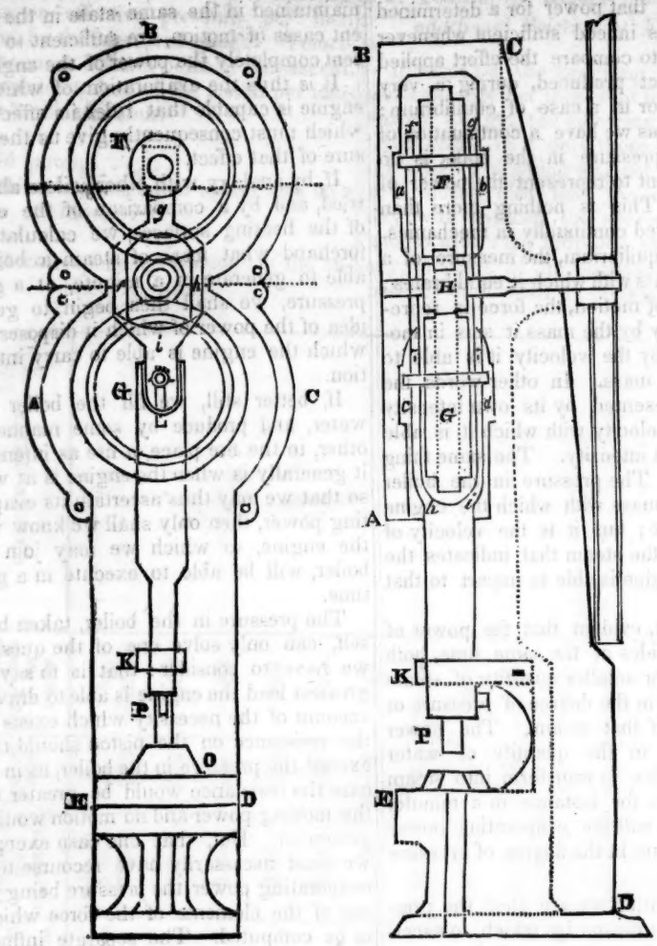
These foundations once established, the effect of an engine may easily be calculated by comparing the force of traction the load requires, which fixes the power the engine must expend, with the mass of power of which it is able to dispose; that is to say, its evaporating power.

(To be Continued.)

HOSKING'S PORTABLE PUNCHING PRESS.

(From the Third Report of the Cornwall Polytechnic Society.)

This machine is intended to facilitate the repairs of steam-packet boilers; it is sufficiently compact to admit of being readily conveyed to any dock or yard where its services may be required. Figs. 1 and 2, are



two vertical sections through the centre of the press, at right angles to each other, in which A B C D E, is a substantial iron frame, cast in two parts, having a space between them to contain two slightly eccentric cog-wheels F and G, whose arbors work in the wrought iron frame *f g h i*, which is firmly connected with the punch P. These wheels are driven by the pinion H, which, like the wheels, may be said to consist of three parts; a central part containing the cogs, and two outside cylindrical portions, whose circumferences in each case coincide with the pitch lines; these, by rolling on each other, keep the cogs at a proper and uniform distance, and prevent the undue strain and irregularity of action which would otherwise attend the eccentricity of the wheels, and consequently vertical movement of thetr centres.

For the purpose of keeping the centres of the wheels in the same vertical plane with the centre of the punch, their arbors are continued into a groove cast in the framing, and shewn at *a b c d*, together with the guide *k*.

The action of this machine will now be readily understood. Motion being given to the fly-wheel, is communicated by the pinion of the wheels F G, which are so arranged that the longest working radius of one, and the shortest of the other, shall be in contact with the pinion at the same time; when the longest radius of the wheel G, is with the pinion, the punch will be at its greatest depression; and when this wheel has made half a revolution from that point, it will be at its greatest elevation The material to be punched should then be placed on the stand O, and at the next half revolution of G, the piece would be forced out.

It is obvious that this machine possesses many other advantages than its portability; and we are inclined to think that in connexion with the steam-engine, it would be found greatly superior to the screw-press generally used for this purpose.

AGRICULTURE, &c.

From the Southern Agriculturist.

ON THE PRIDE OF INDIA TREE, AS AN ARTICLE FOR FENCING.

Dear Sir,—At your request, I furnish you with my observations on the Pride of India Trees, as an article of fencing, in places where timber is scarce and of indifferent quality. I have, myself, been at some pains in cultivating this high valuable tree; and bringing it to that state of perfection, which I have heard it attains, in its native clime. The result of my experience is, that it may be made one of the most useful and profitable fencing and timber trees known to the southern plantation. Our country is becoming, every year, more thickly settled, and as cultivation is pushed on, the vast primeval forests which cover the land, must necessarily disappear before the woodman's axe. The consequence is, that in a few years we will begin to feel the want of the necessary wood and timber for our farming purposes, and see the utility of setting out plantations of the more valuable forest trees. Indeed, I am aware of the existence of this want of timber on some of our sea-islands, and fertile rice lands, and it is particularly to the planters of thos sections that I address these remarks.

The best method of cultivating the Pride of India, that I have yet discovered, is the following. Run a plough in a straight furrow, and return, ploughing up another furrow to the one made, then take a hoe, and at the distance of eight feet, open a hole about one foot wide along the ridge, which fill with well rotted manure from the stable, or heap of compost, into which drop four or five berries. This should be done in March or April. Cover them lightly and attend the young plants as you would cotton, keeping down grass and weeds, and pulling up the weak and slender shoots, leaving but one of the most healthy and vigorous. Go over this twice in the course of three months, with a plough, turning over the furrow to the plants. The young trees will rapidly grow to the height of six or eight feet. During this time, you must occasionally strip off the leaves and lateral shoots, in order to train the stems to a certain length. Keep them merely straight twigs to which they will naturally tend, until the next spring, when you will direct them to grow as upright as possible, keeping down weeds and grass as in the year before. In this year they will attain the thickness of about twelve inches in circumference; and by the next spring the height of twelve or fifteen feet. The growth may, however, be improved by the use of the hoe and manuring. They may now be permitted to put out lateral limbs, suffering the most vigorous to continue, and taking off the weak ones while young, with a pruning knife. This will preserve the quality and beauty of the timber, making it fit in fifteen years for all manner of furniture.

The value of the wood cannot be too highly appreciated. It may be sawed into boards from twelve to eighteen inches wide, fit for almost any purpose, or into wainscoting of the most beautiful shades. It is a light, sonorous wood, not apt to split, and capable of a very high polish. It is entirely divested of any resinous matter, and thereby fitted to receive the most beautiful varnishes. It possesses powerful vermifugous qualties, and thereby fitted for all furniture of the bed chamber, as no bugs or any other insect will infest it. The texture or quality of the wood may be improved by being grown on land of a clay bottom, but will grow well on the loosest sandy loam. It should be raised from the seed in the manner I have described. If transplanted, its tap-roots will never grow, and the quality of the wood is much impaired. Besides, it will be more apt to be blown down, being supported only by lateral roots, these taking their sole pabulum from the rich loam on the surface, and giving to the wood a soft spongy texture.

As an article for fence posts, I can safely recommend it as one of the cheapest and most durable. In this latter quality it approximates more nearly to cedar than any wood I know. It may be planted where the fence is intended to be run, and your rails may be nailed to the body of the tree. The superfluous branches will afford an excellent fire-wood.

The foilage of this tree affords a wholesome provender for cattle. Horses, cows, hogs, sheep, &c. will eat the leaves greedily. When dried and mixed with hay, I know of no better medicine for cattle of every kind. Such are the vermifugous qualities of the entire tree, that I never fail to give it to my animals every spring. A few leaves given to horses once or twice a week, will afford them a most beautiful coa

of hair. A decoction of its root administered in small doses to children every morning for nine days, will effectually destroy worms in them.

A correspondent of yours has already testified as to the excellence of Pride of India leaves and berries as a manure; and also as a preventive to bugs. To his testimony, I can safely add my own. I have tried both experiments, and have experienced the most beneficial results.

With every wish for your success, Mr. Editor, I subscribe myself

COLBERT.

STEAM COTTON MILL.—An extensive steam cotton manufactory is about to be established at Portsmouth, N. H. A committee, previovsly appointed to inquire into the feasibility of the undertaking, reported the following facts:—

The estimated cost of all the machinery for a mill of 10,000 spindles, including gearing, tools, hydraulic apparatus, two Steam Engines of 60 horse power each, and land and buildings, is $164,000; viz:—

Machinery complete, at $10 per spindle,	$100,000
Bobbins, pickers, shuttles, boxes, &c.,	3,000
Belting, main shafting, and drums,	12,000
Cloth room, Presses, and Counting Room,	4,000
Steam apparatus for heating Mill,	1,200
Forcing Pump and Fire Apparatus,	800
Painting, Clothing Cards and Starting Mill,	5,000
Repair Shop and tools,	2,000
Two 60 horse power Engines, Engine House and Boilers,	12,000
Estimated Cost of Land and Buildings,	24,000
Making the amount of fixed capital	$164,000

From actual experience, it is ascertained that the fuel and water to operate the Mill one year would cost about $4000. It is also estimated that a Milll of this capacity would turn off 9000 lbs. of cloth per week, at a profit of $700, or nearly $37,000 per year. This estimate of the profits of the establishment was made by a person having an extensive knowledge of the manufacturing business; but we think it is much less than what would be realized.

At Middlesbro', a few years ago an obsecure fishing village, now become a considerable sea-port town on the river Tees, below Stockton—on laying the foundation for an Exchange, it was stated, among other important facts connected with railways, that that the projectors of the Stockton and Darlington railroad, only ventured to anticipate, as the greatest possible export of coal from the Tees, a quantity not exceeding 10,000 tons per annum;—this successful undertaking has not been ten years in operation, and yet, during the past year, between four and 500,000 tons of coals had been exported from that river.—[Sunderland Herald.]

SOME HINTS ON THE IMPORTANCE OF IMPROVING COTTAGE GARDENS. BY AN OLD FLORIST.

In looking over the last number of your Magazine, I was much pleased with an article from your correspondent, Mr. R. Murray, respecting the neglected state of cottage gardens, or perhaps, more properly the gardens of people in moderate circumstances in life, in the immediate vicinity of Boston. This is an important subject for discussion, and one which requires to be handled by persons who are competent to suggest methods for improving them. I have observed, in travelling through the villages in this neighborhood, many places that lay entirely waste, or but very little improved, that might, by bestowing upon them a small portion of time and care, be made a great source of amusement, if not of profit, to the proprietor or occupant This state of things is apt to strike the eye of persons unaccustomed to such, very unfavorably; and they oftentimes judge precipitately. It is very rare in Britain to see the gardens, even of the poorer cottagers, lie so neglected. A small, neat flower garden in front of the house, in which a few choice flowers are grown, and with the honeysuckle, jessamine, &c., climbing over the walls, and running up the sides and over the door, adds very much to the appearance of the premises, especially if the house is an indifferent one. I have frequently thought, when the subject has occurred to me, that this must in some measure be owing to the very long cold winters which are experienced in this climate, and which prevents gardening from being carried on here but a limited part of the year. Yet, however, I have found, that many plants which I should have expected that the cold winters would have killed, live through them with but little or no protection, and flourish as well as in England.

The horticultural and floral societies which abound throughout Britain, have tended greatly to encourage gardening among the people: numerous prizes are awarded to individuals who are not members, but who produce any thing worthy of exhibition. I have never attended a meeting, but what a part of the room has been set off for the productions of the cottagers; and at certain times, the secretary and two or three members visit all the gerdens within several miles of the place where their meetings are holden; a report is drawn up of the state in which they find them, and a prize is awarded to the person who keeps his under the highest cultivation. By this means emulation is produced, and the neighbor of the person who has gained a prize, begins to devote his leisure hours to the garden, rather than idle them away in places of dissipation; his family also receive more of his company, and the money that would perhaps have been uselessly spent, is applied to some good purpose. I do not know of any thing that ever gave me more pleasure, in travelling through the country, than to see a man, in the cool of evening, cleaning and watering his little garden, with his children playing about him.

I am not aware whether all florists' flowers can be successfully cultivated here; more particularly the picotee, carnation, auricula, polyanthus and ranunculus. They all live through the winters in England without protection, though some persons possessing valuable collections generally give them some covering during a few days of severe weather which sometimes occurs. Whether such flowers can be grown with equal success here, I am not able to state, but undoubtedly many of your readers who are more acquainted with the subject than myself, will give their opinions respecting it. I have always been an admirer of the flower garden, and for many years spent my leisure hours in cultivating many choice kinds, although I never carried it to the extent that many of the "fancy" do. Those persons who have become so thoroughly carried away into the love of florists' flowers as to walk twenty or thirty miles in a hot day in July, to get a sight of a new carnation, and having been gratified with such a view, will almost sell their coats from their backs to obtain a plant, may be truly said to be enthusiasts in the highest degree; but to that class I did not belong; nor do I wish to see any person in this community become so deeply imbued with such a feeling; it would be carrying things too far, and would have an injurious rather than a good effect. But I think that if mechanics, and especially persons employed in manufactories, would spend their leisure hours in the garden, where they have one, and where one could be obtained, they would find it a place of innocent and healthful amusement, and of time well spent. There only wants to be a few examples set, and a stimulous will then be given; and I have no doubt but that florists' flowers of every kind could be produced, and made to take the place of the weeds your correspondent complains of. I feel unable to do that justice to the subject which it requires, and hope that there are many of your readers, who see its importance, and will not neglect to occasionally remind us of it; at a future time, I may state something upon the culture of some kinds of flowers as gathered from my own practice; but as I have now trespassed too much upon your room, to the exclusion of more useful matter, with my best wishes for the success of your Magazine, and a hope that you may be rewarded for your labors, I subscribe myself,

AN OLD FLORIST.

Boston, Feb., 1836.

THE SUBSCRIBER is authorised to sell PAGE'S MORTICING MACHINES, to be used in any of the *Western, Southern*, or *Middle* States, (except New-Jersey,) and also to sell Rights for *Towns, Counties*, or *States*, in the same region, *including New-York*.

MACHINES will be furnished complete, ready to work, and at a *liberal discount* to those who purchase territory, or machines to sell again.

Applications may be made by letter, *post paid*, or personally, to

D. K. MINOR, Agent for Proprietor,
132 Nassau street, New-York.

☞ Terms of *single* machines, $30 to $35, for *common morticing*; and $50 to $60 for HUB machines, which, in the hands of an experienced man, will mortice 14 to 16 setts of common carriage or wagon hubs per day.

☞ WILL be published, in a few days, NICHOLSON'S *Treatise on Architecture*,—Also, PAMBOUR on *Locomotive Engines on Railroads*.

NOTICE TO CONTRACTORS.

JAMES RIVER AND KANAWHA CANAL.

PROPOSALS will be received at the Office of the James River and Kanawha Company, in the City of Richmond, from the 15th to the 23rd day of August, for the construction of all the Excavation, Embankment and Walling not now under contract, together with nearly all the Culverts and the greater portion of the Locks between Lynchburg and Maidens' Adventure.

The work now advertised embraces the twenty miles between Columbia and the head of Maidens' Adventure Pond, the eight miles between Seven Island Falls and Scottsville, and about twenty isolated sections, reserved at the former letting, between Scottsville and Lynchburg.

The quantity of masonry offered is very great—consisting of about two hundred Culverts of from three to thirty feet span; nine Aqueducts, thirty-five Locks a number of Wastes, with several farm and road Bridges.

General plans and specifications of all the work, and special plans of the most important Culverts and Aqueducts, will be found at the offices of the several Principal Assistant Engineers on the line of the Canal.

The work will be prepared for examination by the 25th July; but mechanics, well recommended, desirous of immediate employment, can obtain contracts for the construction of a number of Culverts at private letting.

Persons offering to contract, who are unknown to the subscriber, or any of the Assistant Engineers, will be expected to accompany their proposals by the usual certificates of character and ability.

CHARLES ELLET, Jr.,
Chief Engineer of the James River and Kanawha Company.

NOTE.—The Dams, Guard-Locks, most of the Bridges, and a number of Locks and Culverts, are reserved for a future letting. Persons visiting the line for the purpose of obtaining work, would do well to call at the office of the Company in the city of Richmond, where any information which they may desire will be cheerfully communicated.

The valley of James River, between Lynchburg and Richmond, is healthy. (20—ta18) C. E. Jr.

RAILROAD CAR WHEELS AND BOXES, AND OTHER RAILROAD CASTINGS.

Also, AXLES furnished and fitted to wheels complete at the Jefferson Cotton and Wool Machine Factory and Foundry, Paterson, N. J. All orders addressed to the subscribers at Paterson, or 60 Wall street, New-York, will be promptly attended to.

Also, CAR SPRINGS.

Also, Flange Tires, turned complete.

J8 ROGERS, KETCHUM & GROSVENOR.

ALBANY EAGLE AIR FURNACE AND MACHINE SHOP.

WILLIAM V. MANY manufactures to order, IRON CASTINGS for Gearing Mills and Factories of every description.

ALSO—Steam Engines and Railroad Castings of every description.

The collection of Patterns for Machinery, is not equalled in the United States. 9—1y

RAILWAY IRON.

95 tons of 1 inch by ½ inch.
200 do 1¼ do ½ do
40 do 1½ do ½ do
800 do 2 do ½ do
800 do 2½ do ½ do

FLAT BARS in lengths of 14 to 15 feet, counter sunk holes, ends cut at an angle of 45 degrees, with splicing plates and nails to suit.

soon expected.

250 do. of Edge Rails of 36 lbs. per yard, with the requisite chairs, keys, and pins.

Wrought Iron Rims of 30, 33, and 36 inches diameter for Wheels of Railway Cars, and of 60 inches diameter for Locomotive Wheels.

Axles of 2¼, 2¾, 2½, 3, 3¼, 3½, and 3¾ inches in diameter, for Railway Cars and Locomotives, of patent iron.

The above will be sold free of duty, to State Governments and Incorporated Governments, and the drawback taken in part payment.

A. & G. RALSTON,
9 South Front street, Philadelphia.

Models and samples of all the different kinds of Rails, Chairs, Pins, Wedges, Spikes, and Splicing Plates, in use both in this country and Great Britain, will be exhibited to those disposed to examine them.

4—d7 1meowr

STEPHENSON,

Builder of a superior style of Passenger Cars for Railroads.

No. 264 Elizabeth street, near Bleecker street, New-York.

RAILROAD COMPANIES would do well to examine these Cars; a specimen of which may be seen on that part of the New-York and Harlaem Railroad now in operation. J25tf

FRAME BRIDGES.

THE subscriber would respectfully inform the public, and particularly Railroad and Bridge Corporations that he will build Frame Bridges, or vend the right to others to build, on Col. Long's Patent, throughout the United States, with few exceptions. The following sub-Agents have been engaged by the undersigned who will also attend to this business, viz.

Horace Childs,	Henniker, N. H.
Alexander McArthur,	Mount Morris, N. Y.
John Mahan,	do do
Thomas H. Cushing,	Dover, N. H.
Ira Blake,	Wakefield, N. H.
Amos Whitemore, Fsq.,	Hancock, N. H.
Samuel Herrick,	Springfield, Vermont.
Simeon Herrick,	do do
Capt. Isaac Damon,	Northampton, Mass.
Lyman Kingsly,	do do
Elijah Halbert,	Waterloo, N. Y.
Joseph Hebard,	Dunkirk, N. Y.
Col. Sherman Peck,	Hudson, Ohio.
Andrew E. Turnbull,	Lower Sandusky, Ohio.
William J. Turnbull,	do do
Sabried Dodge, Esq.,	(Civil Engineer,) Ohio.
Booz M. Atherton, Esq.	New-Philadelphia, Ohio.
Stephen Daniels,	Marietta, Ohio
John Rodgers,	Louisville, Kentucky.
John Tililson,	St. Francisville, Lous'a.
Capt. John Bottom,	Tonawanda, Penn.
Nehemiah Osborn,	Rochester, N. Y.

Bridges on the above plan are to be seen at the following localities, viz. On the main road leading from Baltimore to Washington, two miles from the former place. Across the Metawamkeag river on the Military road, in Maine. On the National road in Illinois, at sundry points. On the Baltimore and Susquehanna Rrailroad at three points. On the Hudson and Patterson Railroad, in two places. On the Boston and Worcester Railroad, at several points. On the Boston and Providence Railroad, at sundry points. Across the Contocook river at Hancock, N. H. Across the Connecticut river at Haverhill, N. H. Across the Contoocook river, at Henniker, N. H. Across the Souhegan river, at Milford, N. H. Across the Kennebec river, at Waterville, in the state of Maine.—Across the Genesse river, at Mount Morris, New-York, and several other bridges are now in progress.

The undersigned is about to fix his residence in Rochester, Monroe country, New-York, where he will promptly attend to orders in this line of business to any practicable extent in the United States, Maryland excepted. MOSES LONG.

General Agent of Col. S. H Long.
Rochester, May 22d, 1836. 19y-tf.

PATENT RAILROAD, SHIP AND BOAT SPIKES.

☞ The Troy Iron and Nail Factory keeps constantly for sale a very extensive assortment of Wrought Spikes and Nails, from 3 to 10 inches, manufactured by the subscriber's Patent Machinery, which after five years successful operation, and now almost universal use in the United States, (as well as England, where the subscriber obtained a patent,) are found superior to any ever offered in market.

Railroad Companies may be supplied with Spikes having countersink heads suitable to the holes in iron rails, to any amount and on short notice. Almost all the Railroads now in progress in the United States are fastened with Spikes made at the above named factory—for which purpose they are found invaluable, as their adhesion is more than double any common spikes made by the hammer.

*** All orders directed to the Agent, Troy, N. Y., will be punctually attended to.

HENRY BURDEN, Agent.
Troy, N. Y., July, 1831.

*** Spikes are kept for sale, at factory prices, by I. & J. Townsend, Albany, and the principal Iron Merchants in Albany and Troy; J. I. Brower, 222 Water street, New-York; A. M. Jones, Philadelphia; T. Janviers, Baltimore; Degrand & Smith, Boston.

P. S.—Railroad Companies would do well to forward their orders as early as practicable, as the subscriber is desirous of extending the manufacturing so as to keep pace with the daily increasing demand for his Spikes.

1J23am H. BURDEN.

ARCHIMEDES WORKS.

(100 North Moor street, N. Y.)

NEW-YORK, February 12th, 1836.

THE undersigned begs leave to inform the proprietors of Railroads that they are prepared to furnish all kinds of Machinery for Railroads, Locomotive Engines of any size, Car Wheels, such as are now in successful operation on the Camden and Amboy Railroad, none of which have failed—Castings of all kinds, Wheels, Axles, and Boxes, furnished at shortest notice.

4—ytf H. R. DUNHAM & CO.

PROSPECTUS

OF VOLUME II. OF THE

CHICAGO AMERICAN,

TO BE PUBLISHED SEMI-WEEKLY.

In proposing to establish a SEMI-WEEKLY paper under the old title, but with extended dimensions, the subscriber acknowledges the favors of the past, and solicits the continued patronage of a liberal public.—The reasons that induced him about a year since to establish his weekly paper, operates with renewed and increasing force in favor of his present design.—He shall endeavor, as it was originally intended, to make his paper American in all things; and by identifying itself with the interests and circumstances of Chicago—which from a recent wilderness has advanced to a population of thirty-five hundred—and of the rich, extensive, and rapidly developing country of which it is the emporium, he hopes it may "grow with their growth, and strengthen with their strength."

As a record of passing events, current literature, of the march of agriculture, commerce and manufactures, and especially of the progress of internal improvements, of which this State, by her recent passage of the act for the construction of the "Illinois and Michigan Canal," has commenced her great and auspicious system, it will aim, as ever, to be accurately and early informed, and thus endeavor to consult alike the tastes and wants of the community with which it is identified. With party, as generally understood, it will have as little to do as possible. Its politics will be the Constitution—its party, the Country.

With this brief explanation of its future course, and his thanks for the more than expected encouragement he has already received, the subscriber again ventures to solicit the continued patronage and extended support of all who may feel an interest in the principles here set forth.

It will be enlarged and otherwise greatly improved, and printed on superior paper, and forwarded to distant subscribers by the earliest mails, enveloped in a strong wrapper.

TERMS.—The AMERICAN will be published SEMI-WEEKLY, at $4 per annum, if paid at the time of subscribing; $5 if paid at the expiration of six months, or $6 if payment is delayed to the end of the year.

*** Any person procuring five subscribers and remitting the pay in advance, will be entitled to a sixth copy gratis, or a deduction of TEN PER CENT.

Persons at a distance remitting a $5 bill will receive the paper fifteen months.

*** All sums to the amount of $10 and upwards may be sent through the Post Office, at my expense.

THOS. O. DAVIS.

Chicago, March 25, 1836.

*** Subscriptions and Advertisements for the CHICAGO AMERICAN will be received at the Office of the Railroad Journal, 132 Nassau street, by

D. K. MINOR.

☞ THE NEWCASTLE MANUFACTURING COMPANY, incorporated by the State of Delaware, with a capital of 200,000 dollars, are prepared to execute in the first style and on liberal terms, at their extensive Finishing Shops and Foundries for Brass and Iron, situated in the town of Newcastle, Delaware, all orders for LOCOMOTIVE and other Steam Engines, and for CASTINGS of every description in Brass or Iron RAILROAD WORK of all kinds finished in the best manner, and at the shortest notice.

Orders to be addressed to

MR. EDWARD A. G. YOUNG,
Superintendent, Newcastle, Delaware.

feb 20—ytf

NOTICE OF THE NEW-YORK AND ERIE RAILROAD COMPANY.

THE Company hereby withdraw their Advertisement of 26th April, in consequence of their inability to prepare in time, the portions of the line proposed to be let on the 30th June, at Binghampton, and on the 11th of July at Monticello. Future notice shall be given, when proposals will be received at the above places, for the same portions of the road.

21—tf JAMES G. KING, President.

AMES' CELEBRATED SHOVELS, SPADES, &c.

300 dozens Ames' superior back-strap Shovels
150 do do do plain do
150 do do do cast steel Shovels & Spades
150 do do Gold-mining Shovels
100 do do plated Spades
50 do do socket Shovels and Spades.

Together with Pick Axes, Churn Drills, and Crow Bars (steel pointed,) manufactured from Salisbury refined iron—for sale by the manufacturing agents,

WITHERELL, AMES & CO.
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N. B.—Also furnished to order, Shapes of every description, made from Salisbury refined Iron. 4—ytf